THERAPEUTICS OF CIRCULATORY DERANGEMENTS

VON ZIEMSSEN'S

HANDBOOK

OF

GENERAL THERAPEUTICS

IN SEVEN VOLUMES—VOL. VII.

THERAPEUTICS

OF

CIRCULATORY DERANGEMENTS

BY

PROFESSOR M. J. OERTEL, M.D.

OF MUNICH

LONDON

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1887

THERAPEUTICS

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CIRCULATORY DERANGEMENTS

WEAKNESS OF THE HEART-MUSCLE
INSUFFICIENT COMPENSATION IN CARDIAC FAILURE
FATTY HEART AND OBESITY
ALTERATIONS IN THE PULMONARY CIRCULATION
&c.

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With Thirty-seven Illustrations

TRANSLATED BY

EDWARD J. EDWARDES, M.D. Lond., M.R.C.P.

SCHOLAR IN NATURAL SCIENCE, ST MARY'S HOSPITAL MEDICAL SCHOOL
ASSISTANT-PHYSICIAN TO THE NORTH-WEST LONDON HOSPITAL
PHYSICIAN TO THE ST PANCRAS AND NORTHERN GENERAL DISPENSARY

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TRANSLATOR'S PREFACE.

A FEW words on the proper scope of this work may not be out of place, in order to prevent misconception of the Author's aim.

The main subject of this work is chronic venous stasis and its consequences, by whatever cause induced, but especially in connection with obesity and fatty heart. Venous stasis is a common consequence of various pathological conditions, enumerated on the first page of the 'Introduction,' and valvular failure of the left heart is there mentioned as one of its causes; but there are a great many more, and the work must not be looked upon as a work on the treatment of heart-disease *per se.* The reproach which has been made that various cardiac lesions find no mention in this treatise is, therefore, quite beside the question, as the title alone ought to have shown.

The chief clinical history (Case I.) in the book is not a case of heart-disease, properly speaking; it is the case of a medical man affected with a kyphotic curvature of the spine, which caused contraction of the thorax. Hence the circulation through the lungs was interfered with, cramped up as they were in a smaller space than natural, and enlargement of the right side of the heart and ultimately general venous stasis gradually ensued. Most of the cases are cases of obesity and fatty heart, and out of thirty cases treated by the Author on his method there are only two of valvular disease.

This work is a splendid illustration of the enormous influence we can bring to bear on some chronic morbid conditions by purely physiological means, apart from the use of drugs. Dr. Oertel acknowledges that Dr. Chambers was the first to restrict the supply of liquids in obesity; in the 'Banting' regimen this supply was not interfered with. But the scientific examination of the treatment of obesity has never hitherto been so thoroughly made, nor has the necessity for diminishing the volume of the blood by the energetic removal of water from the system, and for strengthening the heart by systematic severe exertion, ever been so clearly demonstrated and experimentally established. The abundant experiments on increased excretion of water, on the influence of a rich albumen-supply upon albuminuria, on the various influences affecting albumen-destruction and albumen-conversion within the body (Pettenkofer and Voit), on the influence of long-continued exertion upon blood-pressure and upon arterial tension and fulness, &c. &c., are of the highest interest.

Medicine can never be made an exact science, for it is also an art, but a work of this kind constitutes a distinct gain in that direction.

E. J. EDWARDES.

17 ORCHARD STREET, W.:
August 1885.

PREFACE.

Disorders of the circulation form no disease *sui generis*, but depend either on diseases of the vascular system, or on more or less irreparable conditions of the organism elsewhere, by which a proper distribution of the blood, and the preservation of the hydrostatic balance between the arterial and venous systems, are interfered with.

The treatment hitherto has proceeded on the perfectly correct principle of selecting as the immediate point of attack the lesion forming the basis of the circulatory disorder, and allowing the balance between the different circulatory systems to adjust itself. The unfavourable results hereby attained are caused chiefly by our inability to reach the fundamental lesion, or else by the inefficiency of the means employed.

Accordingly, it was still open to experiment to deal directly with the accumulation of blood in the vessels, and to correct the circulation in a mechanical manner, without considering the causes underlying the circulatory disturbances. This experiment is carried out in the following work. And since, wherever disorders arise in connected blood-circuits, we have to deal for the most part with physical processes, these will be opposed by physical means; the hydrostatic balance will be restored mechanically, and by reduction of the fluids of the body. After this, the second part of the problem will deal with the *causes* of the circulatory derangement, and, so far as they are

amenable to treatment, their correction, or the narrowing of their influence. We here distinguish between perfectly irreparable alterations of the vascular apparatus, and compensations naturally arising for the removal of some of the consequences of those alterations. The restoration of these compensations when lost, and the release of the consequently obstructed circulation, help to make up the task before us.

The different therapeutical measures and results hereto belonging did not proceed from a series of experimental investigations, as might appear at first sight, nor do they hang together like the links of a chain, but, as is mostly the case in this kind of work, out of one fact others developed side by side, and from one standpoint other points were chosen for attacking the diseases accompanying the circulatory disorders. First the fact was given, and only in succeeding years was its explanation experimentally established. The first treatment detailed was a venturous experiment at the risk of life. In this case there was no longer time to discover by preliminary investigations a means by which the threatening disturbances could be removed, but quick and bold action on firm conviction was necessary, if the patient's life was to be saved: the why and wherefore had to be deferred a while.

In this case, first of all the wide influence of the fluid-supply upon circulatory derangements was recognised, and the theoretical assumption was fully established that the processes here occurring were purely physical, and that physical interference was necessary. A further result was the rapid oxidation of the deposited fat, owing to diminution of the fluids of the body, which diminution, together with the proper diet, will henceforward form a chief factor in the reduction of obesity. It is only too well known that the dietetic methods hitherto employed against fatty heart and obesity have proved partly inefficient, partly directly prejudicial, and that the endeavours are manifold to eliminate the danger accompanying the re-

moval of fat from the heart. The scientific foundation of the new method, and its application to the treatment of obesity, occupy, therefore, a great part of this work. But amongst its most important results is the gymnastic strengthening of the heart-muscle in debility, atrophy, uncompensated valvular failure, or insufficient or failing compensation; also in fatty degeneration, and fatty deposition and infiltration. The powerful influence we can thus exercise upon the heart is established both experimentally and by the results of treatment.

The peculiar form of this treatise is owing to the particular way in which it was put together. As already mentioned, the therapeutic methods here laid down were not gained from preliminary physiological and pathological experiments, but only after the measures founded on theoretical conclusions had been carried out, and the expected results obtained, could their essential elements be subjected to a careful scientific examination. Consequently the experimental investigations on which the method is based are more recent than the method itself.

That the Author has waited nine years before publishing this work is due partly to outside causes, other works requiring completion, but chiefly to the desire of observing for several years both the immediate and ultimate results of this new and hitherto undeveloped method, in order to ascertain if stable conditions had been procured, or if the improvement in each case was only transitory. Moreover, the Author made repeated confidential communications to the profession in Munich, on the therapeutic method established by him, and thus confirmed his own experience by the conclusions of others. After the perfect success of these attempts had been proved for nine years, and the hydrostatic balance in the cases of circulatory derangement coming under treatment had been perfectly preserved, the time came for publishing what had been discovered.

In the publication of this work is fulfilled the ardent desire

of the Author for many years, to dedicate a labour which has taken up so much of his life to his illustrious teachers

Geheimrath v. Pettenkofer and Professor v. Voit,

whose labours have laid so much of the foundation for his own investigations, and to

Obermedicinalrath v. Ziemssen,

with whom he has been united in scientific activity for fifteen years, and to whom he is equally indebted, as a token of his gratitude and deep respect.

THE AUTHOR.

MUNICH: *May* 1, 1884.

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OF

THE SEVENTH VOLUME.

THERAPEUTICS

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INTRODUCTION.

SYMPTOMS AND COURSE OF CIRCULATORY DERANGEMENTS.

If the hydrostatic balance of the fluid columns in the various tubes of the body is destroyed, if the inflow of blood into the heart no longer corresponds with the outflow, and the pumping apparatus is no longer able to drive onward the accumulated fluid which reaches it, disorders will arise in the circulatory apparatus, which, if no compensation be afforded, must entail upon the organism the most serious consequences.

The immediate causes which induce these disorders lie either in the pumping apparatus itself, in the heart-muscle, in its weak contractions and insufficient propulsive power, in imperfect closure of its valves and narrowing of its orifices, or else in one or the other tubular system, when from restriction of its space it can no longer take up the quantity of fluid that it should. Such causes are, *weakness of the heart-muscle, fatty heart, general obesity, and valvular failure of the left heart* (*mitral or aortic*). To these may be added *derangement of the pulmonary circulation* from emphysema, chronic interstitial pneumonia and bronchiectasis, various curvatures of the spine (scoliosis, kyphosis), and pressure of pleuritic exudations and tumours, either developing within the thorax or invading it from without.

Although it may be presumed that the consequences of these morbid conditions are thoroughly well known, still a complete exposition of them must be attempted here, both in regard to a survey of the general derangements and the treatment to be deduced thence.

The *immediate consequences* of vascular derangements of

the kind indicated are of a *purely physical* nature. Either from failure arising in the pumping apparatus or from reduced size of part of the tubular system, the fluid streaming in on the one hand is no longer driven onwards in equal quantity on the other, but is dammed back, causing a disproportionate distribution of blood in the vascular apparatus. The lesser circulation is presently overcharged with blood, the outflow from the veins of the greater circulation is more and more impeded, larger waves of blood are thrown back, while the blood flowing from the lungs and propelled in equal quantity into the aorta gradually diminishes, and the arterial pressure becomes lowered in the systemic circulation. Owing to the accumulation of blood in the lungs the vessels there are full to distension, and, under the increasing pressure of the blood columns against their containing walls, they expand and form projections (ectases), which are most marked in the networks surrounding the alveoli, since the pressure of the air is insufficient to prevent the encroachment of the distended vascular walls upon the alveolar spaces. If the capillary walls can no longer resist the internal pressure, capillary hæmorrhages occur, partly into the interstitial tissue, partly into the alveoli, or else more or less stasis and diapedesis of red corpuscles, which by metamorphosis of their colouring matters cause gradual pigmentation of the lungs. Simultaneously with the chronic hyperæmia, hyperplastic and hypertrophic processes develop in the tissues, now infiltrated with abundant nutritive fluid. The parenchyma of the lung is enlarged, there is increased formation of connective tissue, and carnification ensues.

Similarly in the systemic circulation the increased hydrostatic pressure from the obstructed blood columns will influence the circulation of the glandular organs of the abdomen, the spleen, the liver, and especially the kidneys, causing chronic hyperæmia, stasis and swelling, with derangement of the secretory, and still more of the excretory activity of the organs last named.

Finally, wherever the circulation is at its lowest ebb from lowered cardiac action, and the pressure of the blood columns in the veins is most felt in the capillary network, there will be a proportionate transudation of serous fluid with œdematous

infiltration of the cellular tissue (first noticeable in the lower limbs), owing partly to the hydræmia, partly to the resulting nutritive derangement of the vascular walls.

A very rapid development of these symptoms is naturally obviated in most cases by *secondary compensations*—cardiac compensatory hypertrophy—which effect an adjustment of the deranged hydrostatic balance, and delay the terminal symptoms for a long time.

The period during which the invasion of threatening symptoms is thus deferred varies in different cases. Excepting malignant thoracic growths and severe pleural effusions, it is shortest in heart disease, especially mitral insufficiency and stenosis after acute rheumatism, &c. On the other hand it is longer in fatty deposition on and fatty infiltration into the heart, where perfect recovery is still possible. Circulatory disorders, which are caused by scoliosis or kyphosis (due to rickets or other disease of the spinal column, either congenital or occurring in early childhood), only reveal themselves later on, at the age of twenty, thirty, or forty, and even then many years may elapse before terminal symptoms arise. It depends chiefly on the amount of spinal curvature, and with it the degree of diminution of the thoracic space and the consequent compression of the lungs, inasmuch as extreme compression will quickly cause circulatory derangement. The resistance of the patient's organs and tissues upon which the alterations of blood-pressure pathologically act, is greatly determined by the condition of health, and these alterations show themselves earlier in spanæmic, rachitic, and scrofulous patients, than in strong and otherwise healthy individuals in whom such derangements are caused by injury to the spinal column in childhood. Such cases maintain for years a healthy condition corresponding to their nutrition and strength generally, and even the shortness of breath caused by their diminished pulmonary capacity is scarcely perceptible beyond a slightly increased frequency of respiration. More decided symptoms are late in their appearance, and then increase forthwith in number and intensity. This adaptation of the organism for decades to the derangement of the hydrostatic balance, and the succeeding rapid and general increase of the disorder, are of the highest interest. In the

following pages we will try and describe the usual career of development in most cases, whatever may be the underlying cause.

The *earliest symptom* that excites the patient's attention is an unusual *shortness of breath*, which rapidly increases. Temporary exertion, such as ascending a flight of stairs, renders the patient breathless, and compels him to stand still; he feels oppression at the breast, and palpitation of the heart, hardly noticeable at first. He tries to temporise matters by walking slowly and resting frequently during any ascents, but without getting rid of his symptoms, which are, however, more troublesome than alarming as yet. Later on, he avoids long walks or the ascent of several flights of stairs, wherever possible, because then the dyspnœa, oppression, and palpitation painfully increase. The vital capacity, which in disease of the spinal column is already lowered by the diminution of the thorax and the compression of the lungs, is still further affected by the stagnation of the blood in the lesser circulation. In such cases the above-mentioned alterations of the lung tissue gradually develop in one way or another; the chronic hyperæmia leads to capillary ectasis in the alveoli and to hypertrophy of the lung, with diminution in size or more or less obliteration of the alveoli. The respiratory surface of the lungs and the decarbonisation of the blood depending thereon become more and more restricted, so that any slight further demand on the breathing leads at once to dyspnœa, and by-and-by the venous stasis is announced by decided cyanosis. The heart can hardly cope any longer with the inflow of blood from the great venous trunks. It contracts rapidly and imperfectly, and irregularly drives varying quantities of blood into the aorta, under varying and decreasing pressures. The blood volume in the arterial system is thus still further lessened, while the stasis and pressure in the veins of the systemic circulation continue to increase. The spontaneous palpitations, at first only occasional, are now more frequent, and occur without cause, while sitting quietly or lying in bed, and without any previous indulgence in stimulants, or previous mental emotion; the patient is waked from sleep by violent palpitations; while alcohol induces them at once, and if taken in the evening entails a sleepless night. The pulse, which previously was only poor and small, from im-

perfect filling of the arteries, now becomes irregular and jerky, and shows the derangement of the cardiac movements, even when the patient is not aware of it at the time.

Increased perspiration sets in simultaneously with the above. Copious sweating is induced by slight exertions—going up stairs, walking quickly, finally even by a short walk on level ground. The patient's skin is moist after the slightest exercise, the face even in winter is bathed in sweat after the slightest effort, the hair is moist, and the increased cutaneous activity is shown elsewhere on the body, so that the feet may take to perspire, a symptom which may never have troubled him before.

The *urine*, on the other hand, *gradually diminishes* with the increased sweating, and if it escaped the patient's notice before, his attention is now drawn to the striking decrease in the quantity passed during the twenty-four hours. If such urine be examined for albumen, it will be found in greater or less quantity, and if the physician had had an opportunity by chance of examining it long before he would probably have found it, especially since transitory albuminuria may occur years before the invasion of violent symptoms and while the patient is apparently in the best of health.

The respiratory apparatus by-and-by shows fresh derangements. Not only has the stasis induced pathological alterations in the parenchyma of the lungs, but the *bronchial mucous membrane* has undergone alterations under the influence of the chronic hyperæmia. Its veins are distended, and its tissue, infiltrated with serum, swollen, and loosened, becomes easily inflamed by irritation from without. Even patients who have never suffered before from cough now show a remarkable tendency to inflammation of the respiratory mucous membrane. Cough and huskiness arise after the slightest chill, on the approach of winter, on breathing irritating vapours, tobacco smoke, or dust; and any nasal or laryngeal catarrh speedily becomes bronchial with more or less fever. There is a free secretion of watery mucus, causing râles, which may be heard all over the chest, and expectorated only by severe fits of coughing and violent efforts. The previous shortness of breath now deepens to the most tormenting dyspnœa. The respiratory

process, already considerably deranged, is still further impeded by the serous infiltration and swelling of the bronchial mucous membrane, and the accompanying mucous secretion. Gaseous exchange becomes impeded, and the slight cyanosis which previously revealed the circulatory derangement rises to lividity of the mucous membranes and skin. The bronchitis always runs a favourable course at first, till a fresh irritation induces fresh inflammation. In other and rarer cases it gradually extends, fresh bronchi are continually implicated, the breathing is more inefficient, the suffocative attacks are more numerous and give place to a permanent dyspnœa, and secondary œdema of the lungs quickly causes death.

In a relatively short time the difficulties in the onward movement of the blood continue to increase, and the previous compensations become altogether insufficient. The symptoms of stasis are more alarming than ever; even a short walk on level ground causes breathlessness, and after twenty or thirty steps the patient is quite exhausted; the respirations are frequent, superficial, irregular, and interrupted; palpitation readily occurs, and if the patient tries to go any farther, increases to violent action, with sense of oppression at the breast. Complete want of breath compels him to stand still and rest till the excitement is over, till the heart beats more quietly and the breathing is slower and deeper. Gradually the distress lessens, and the storm abates, only to break out afresh perhaps after two or three minutes, if the patient is not very careful. Before such a degree of dyspnœa and palpitation is reached, the patients accustom themselves to stand still, till the commencing excitement is allayed. They frequently and apparently without motive interrupt their walk, and direct their attention to any neighbouring object, in order not to attract attention to themselves. By regulating the breathing, so that each step is accompanied by a respiration, the attacks are often staved off. Alarming as they are at any time, they culminate on the attempt to ascend a flight of stairs or a slight elevation. After climbing a few steps the patient is quite spent; the irregular, almost suppressed, respiration and the severe hammering palpitation increase the dyspnœa and alarm; he is speechless or jerks out a word or two at a time, the sweat

stands in beads on the forehead, the head is congested, there is a sense of constriction of the chest, and a severe feeling of weight is felt over the manubrium sterni and either infraclavicular fossa, causing him to feel as if his breast would burst. The exertion carries fresh waves to the *blood accumulated in the great venous trunks*, and causes still greater pressure on the right heart, as if the over-stretched vascular walls were about to give way the next moment. I have repeatedly had occasion to observe these symptoms. Wherever the stasis is so severe as this, it is proportionately diffused in its effects, and the intrathoracic pressure is felt over a wider and wider area. There is a vague sense of weight in the hypochondriac and lumbar regions, and a sense of dragging in the iliac region, such as is felt when the breath is held strongly. If the ascent be continued still further, pressure is felt in the bladder with an almost uncontrollable desire to urinate, and even in the rectum, while all the respiratory muscles make convulsive efforts. The want of breath reaches its climax, the last supply of oxygen is at once used up by the muscles, the patient avoids every movement, leans on his arms to expand his thorax more fully, and awaits in a standing position the end of the semi-suffocation and cardiac excitement. Every attempt to go on induces an attack of suffocation, while sitting down increases the oppression at once by pressure upwards of the abdominal organs, and he is compelled to stand up again.

The whole series of these symptoms caused by obstruction and stasis of the pulmonary circulation, will be increased by any influences which mechanically cause *any further encroachment on the thoracic space*, and the original lesion will sink into the background more and more as the existing disorders are greater. With a pulmonary capacity of only 1,100 or 1,200 c.cm., a slight fresh compression of the lungs is enough to cause great dyspnœa. Every pressure, whether acting from below (abdominal), or from above and externally, suffices to produce it. The patient finds that exertion is most troublesome when the stomach is distended by even a moderate meal and presses against the lungs, or when the thorax is burdened (especially in cases of spinal curvature, when pressure is felt more) by heavy clothes, or anything carried by the patient,

even an open umbrella; stooping, whereby the abdominal contents are pressed upwards against the thorax, causes much embarrassment. When the pressure of the atmosphere is greater, as in high winds and storms, walking and easy breathing are quite out of the question, and oppressive sense of anxiety and suffocative attacks supervene.

Owing to the small vital capacity, which may be reduced to the above amount or still lower, the patient has but *a small amount of air at his disposal for speech.* He speaks in short sentences mostly, and every longer period is interrupted by several adroitly interposed pauses for breath.

It is evident that *the circulatory disorders in other organs also* will undergo alteration in proportion to the increase of the above symptoms. From time to time a sense of weight arises in the loins, connected with a peculiar sensation difficult to describe, without evident cause or marked increase of the general stasis from exertion, &c.; and not seldom large quantities of pale or colourless urine are voided, 12 or 24 hours afterwards, often slightly albuminous. The quantity of urine passed daily is more variable than before, and after excretions of 35 to 50 oz. in the day it may diminish next day or the day afterwards to 27 oz. or less of dark-coloured, highly acid urine, while the amount of fluids taken by the patient may have been constant. The pressure in the venous trunks of the greater circulation, especially of the blood columns of the lower limbs, by-and-by causes alterations in the distant capillaries exposed to this pressure, and in the vulnerable walls of the smaller vessels. Along the front of the shin, about the malleoli, and later on over the dorsum of the foot, numerous small rust-coloured spots arise, of pin-head size. At first discrete, they soon become confluent in patches of half an inch or more across, and these again coalesce to form large rust-coloured patches over the whole front of the leg, uniting with those at the sides. Like the pigmentation of the lungs, this appearance is caused by capillary stagnation, with hæmorrhage and stasis and diapedesis of red corpuscles, the colouring matter of which forms a pigmentary deposition. I have repeatedly noticed these patches in heart disease (valvular failure of the left heart and fatty heart), and in compression of the lungs. Natur-

ally they are unaffected by local treatment. When once these symptoms have appeared, before long there will be copious exudation of serum, and swelling in the parts most disposed thereto. But a very gradual œdema may arise in the subcutaneous connective tissue of the lower third of the leg without any precursory local signs. It soon becomes unmistakable in the eyelids and face also, which seem *more or less swollen*, and the pale, œdematous, and partially cyanotic skin (together with the lividity of the mucous membranes) completes the picture of extreme circulatory disorder.

We have now reached the end of the group of symptoms here interesting us. If the disease advance any further, a complete cure is out of the question—death is the inevitable result.

It lies, however, within the limits of our problem to bring *the possible consequences* of circulatory disorders nearer into view, and to enquire whether they can be opposed at a time when the latter have not as yet become so threatening. Apart from intercurrent diseases and apoplexy in corpulent subjects, circulatory disorders, whether owing to obesity, fatty heart and weakness of the heart muscle, or in consequence of valvular failure, or compression of the lungs with obstruction of the smaller circulation, cause death, in the first place by *secondary kidney disease and dropsy*, secondly by *sudden cardiac paralysis.*

The cause of the *secondary kidney disease* is evident enough—it lies almost exclusively in the pressure-alterations of the renal circulation, in the lowering of the arterial and raising of the venous pressure, in arterial anæmia and venous stasis. To overcome these causes, or even to postpone for long the dropsical phenomena (which finally put an end to life by hydrothorax, hydropericardium, or œdema of the lungs or brain), we must institute a balance between the arterial and venous pressures, and as this forms part of our problem, it will be attained more or less according to our success in the solution of this.

If death occur from *cardiac paralysis*, this is either due to fatty increase and infiltration, atrophy and fatty degeneration of the heart, or else the autopsy gives no explanation, and,

except as to the hypertrophy, the heart muscle shows a normal condition of its fibres. In such cases (most frequent in hypertrophy of the right ventricle after kypho-scoliosis) the cause of death lies in *exhaustion of the cardiac muscle*, and *paralysis of its nervous system* induced by the *inability to cope with the great quantity of blood reaching it*, and the *resulting intracardial pressure*, as I would especially emphasise. We must seek the mechanical causes of the cardiac insufficiency (the fibres of the heart and even its valves being still intact), and of the final cardiac paralysis, in the symptoms above depicted, and the appearances and sensations, most carefully observed by myself, which such patients experience as the blood accumulates more and more in the right heart; in the enormous pressure in the right heart and great venous trunks on slight exertion, in the increasing want of breath, which no longer suffices even during rest, and in the ineffectual efforts of the heart to drive onward, by violent, incomplete, and irregular contractions, the surging blood into the already overcharged lungs. To these must be added, want of oxygen and excess of carbonic acid in the blood, by which the cardiac energy is lowered and paralysis is favoured. Cardiac exhaustion may be hastened, if not directly induced, by over-effort of the cardiac muscle from long-continued bodily exertion, when the accumulated and stagnant blood in the right ventricle is increased still more in volume.

When we pass on to the treatment of circulatory derangements, we shall take into account the earlier or later appearance of these terminal symptoms, and it behoves us to look around in time for means to prevent or delay as long as possible the threatened result.

How far we may be successful in this must be left in the first place to the following experimental investigations and therapeutical endeavours.[1]

[1] J. Seitz, 'Zur Lehre von der Ueberanstrengung des Herzens,' *Deutsch. Arch. f. Klin. Med.*, vols. xi. and xii.; Schulz, *Beiträge zur Pathologie u. Therapie der myopathischen Erkrankungen des Herzens*, Tübingen, 1865; H. Kurzak, *Ueber den Tod durch Herzermüdung bei Hypertrophic des rechten Ventrikels infolge von Kypho-Scoliose*, Inaug. Dissert., Munich, 1883.

Statistics.

The material which gave rise to the design and execution of the method of treating circulatory derangements which is detailed in the following pages consisted of thirty cases, between the years 1875 and 1884, in which from one fault or another in the circulation there was disturbance of the hydrostatic balance.

These various cases are arranged in the following manner according to the underlying causes:—

	Cases
a. Fatty heart and obesity	15
b. Hypertrophy and fatty degeneration of the heart-muscle in connection with corpulency	2
c. Hypertrophy and fatty degeneration of the heart-muscle, general obesity, emphysema and asthma	2
d. Fatty heart with moderate hypertrophy, corpulency, gout, occasional præcordial attacks	1
e. Ancient emphysema with hypertrophy and fatty degeneration of the heart-muscle, great œdema	1
f. Pressure of a bilateral parenchymatous strumous enlargement on the great cervical vessels, hypertrophy of the heart, and asthmatic attacks	2
g. Mitral insufficiency and stenosis, partial cardiac hypertrophy, and insufficient compensation	2
h. Compression of the lungs with right cardiac hypertrophy, partly complicated with bronchitis, in consequence of shortening of the spinal column	4
i. Anæmia complicated with cardiac debility and atrophy of the heart-muscle	1
	30

Of these cases, a perfect cure resulted in all fifteen cases of group *a*. A relative cure with establishment of a sufficient compensation was obtained

in both cases of group *b*,
in the case of „ *d*,
in three cases of „ *h*,
in the case of „ *i*.

In all the above, compensation of the stasis was afforded in such a manner as to remove all subjective troubles, and the invasion of the terminal symptoms which previously threatened has so far been indefinitely postponed.

Within the past eight years there have died—

1 patient in group *b* (man, æt. 67, cerebral apoplexy);
1 „ „ *e* (man, æt. 38, tuberculosis with hereditary disposition—see 'Clinical Histories');
1 patient in group *h* (girl, æt. 17, scoliosis of dorsal vertebræ, croupous pneumonia).

In order now to give a special clinical picture, and to afford definite points of connection for our problem, to be further developed, I will select one of the above cases, in which the symptoms depicted were most striking, and the observation of which was easiest during the whole course of the disease and the fulfilment of the therapeutical task.

CLINICAL HISTORY. Case I.

The patient, Dr. N——, is a physician practising in M——, of a healthy family without any hereditary affection, and the members of which, except those attacked by any special diseases, without exception all reached a good old age. He was strong and healthy in childhood, having no sickness worth mentioning up to the age of four years. He then suffered apparently from fracture of the spine caused by a fall from a considerable height, and only a few months after he was pronounced cured by his medical attendant he sustained a second injury through a severe fall on his back caused by a blow from another boy.

Henceforward the child's strength failed; he was confined to his bed for years, and lost his healthy appearance and plumpness. The upright position without supporting himself by leaning against something was wearisome to him; so was walking, which soon caused pains in the loins and shortness of breath, and any bodily exertion soon caused exhaustion. The consequences of the spinal injury were shown by an inequality, which soon developed to a kyphotic curvature. From this time he was never free from pain. The slightest shock to the spinal column, sitting down quickly, missing a step, even laughing, caused pains which made him clutch any neighbouring object to steady himself by. Riding in a carriage was only possible when he was allowed to stand up in it; the jolting of the spinal cord on sitting down gave him such pains that he had to stand up or else abandon the journey.

The reduction of the thoracic space by the spinal curvature had for its consequence, as the first circulatory disturbance, palpitation of the heart, together with a short puffy respiration, especially audible on walking. All long-continued movement was impossible from the pain in the spine, and compensations only slowly developing procured a circulatory balance sufficient for the time. The spinal pains only left him altogether at the age of fifteen, when walking, ascending stairs, and carriage exercise were no longer prevented. Jolting of the spinal column, as by jumping, or a slight blow, now gave him no pain, and only short-windedness and palpitation on walking much and rapidly betrayed the circulatory disorder.

The *nutritive condition* was but moderate under the circumstances. He was never fat, though there was a disposition to corpulency in the family. The blood-formation was backward; he looked pale and anæmic. His muscular strength was good; the appetite, digestion, and action of the bowels were all normal.

As to his food, it was mainly a flesh diet; breadstuffs were less relished. His drink up to the age of twenty was almost entirely water, and that only when required by thirst, so that the quantity of fluid taken into the system apart from the watery contents of the solid food was but moderate, not exceeding 1,500 grammes as a maximum (52 ozs. in the twenty-four hours).

Approximate Estimate of Water-supply.

Morning :—						
One cup of coffee with milk	=150	grammes,	containing	water	=137·5	grammes
Mid-day :—						
Water about	=100	,,	,,	,,	=100·0	,,
Afternoon :—						
One cup of coffee . .	=150	,,	,,	,,	=137·5	,,
(Or milk	=250	,,	,,	,,	=218·5	,,
Or water	=150	,,	,,	,,	=150·0	,,)
Evening :—						
Water	=200	,,	,,	,,	=200·0	,,
Total :—	600	,,	,,	,,	=575·0	,,
or	700	,,	,,	,,	=656·0	,,
or	600	,,	,,	,,	=587·5	,,

Hence we obtain an average daily supply of fluids =633·0 grammes, containing water =606·2 grammes. The water reckoned in the solid food can hardly be more than 800·0 grammes. Total: 1406·2 grammes of water in twenty-four hours.

On going to the university, and later on when engaged in practice, he became accustomed to other fluids, beer and wine in large quan-

tities, while the supply of solids was not out of proportion to his age and the further development of the body.

From the year 1864 an increase of size and weight occurred with the altered mode of life of the patient, and a general increase of the subcutaneous fat was noticed, which increased steadily, though slowly, up to the year 1875. If now we compare the daily supply of fluids with the earlier amount above given, we remark a great difference.

It will not be difficult, judging by the later circumspect investigations of the patient, to make an approximate calculation of the relative weights of the foods taken daily by him during these years, and of the amount of water supplied in the food and drink. It will be seen from the following table that the fluids taken amounted to 4,325 grammes during the twenty-four hours, or *about seven times as much water as he used to take when he was younger* passed daily into his circulation. The contained water amounted on an average, in the fluids, to 3718·8 grammes; in the solids to 864·2 grammes, giving a total of 4583·0 grammes (=161·6 oz.), in contrast to the 1406·2 grammes (49·6 oz.) taken in his earlier years.

All this fluid, a sevenfold increase on the previous amount, had to be overcome daily by the heart, and to pass through the vascular apparatus (much reduced in capacity from the obstruction to the pulmonary circulation).

Under such circumstances it becomes a question whether such a quantity was entirely excreted by the skin and kidneys, or whether some of it, if only a minute portion, did not rather remain in the circulation and increase the stasis. So far no investigation had been made on this point. The patient remembers that there were already irregularities at that time in the urinary excretion; it varied much in quantity independently of the amount of fluid taken, being sometimes scanty and dark, and at other times copious and colourless. But if he drank more than usual during the day, the quantity passed at night was always larger, though it never quite corresponded to the amount of fluid imbibed, and for two or three days afterwards, when the usual quantity of fluid or even less was taken, he still passed a larger quantity of urine, sometimes strikingly so.

When in 1863 the patient began practice as a medical man, he was perfectly able to undergo the necessary exertion, and neither walking for hours in the streets, nor the frequent ascents of two, three, or four flights of stairs caused any further results beyond an increased frequency of breathing and slight palpitation. It was only after some years that the symptoms of circulatory derangement already detailed showed themselves, and increased the difficulty of his practice, which had meanwhile developed considerably. More-

Table showing the Amount of Water in the Food and Drink, in Grammes.

Fluids	Quantity	Water contained	
		Minimum	Maximum
Morning			
Coffee	112·5	105·0	105·0
Milk	37·5	32·7	32·7
Water	250·0	—	250·0
Forenoon			
Beer	500·0	453·0	453·0
Mid-day			
Beer	500·0–1000·0	453·0	906·0
Afternoon			
Coffee	112·5	105·0	105·0
Milk	37·5	32·7	32·7
Water	500·0–750·0	500·0	750·0
Evening			
Tea	200·0–240·0	198·5	238·0
Milk	50·0–60·0	43·7	52·4
Beer	1000·0–1500·0	906·0	1359·0
Wine	375 0	—	·324·3
Total	3675–4975	2829·6	4608·1

Solids	Quantity	Water contained	
		Minimum	Maximum
Morning			
Bread	70·0	24·9	24·9
Forenoon			
Bread	50·0	14·0	14·0
Sausage	125·0	—	89·8
Mid-day			
Soup	360·0	304·9	304·9
Fish	100·0	—	76·5
Flesh meat	150·0–200·0	87·0	113·0
Side dishes	100·0	75·6	80·2
Vegetables	50·0–100·0	35·0	—
Salad	50·0–100·0	—	94 0
Flour foods	200·0	—	90·0
Bread	25 0	7·0	7·0
Evening			
Roast meat	150 0	—	87·0
Smoked ham	70 0–100·0	19·5	—
Smoked tongue	70·0–100·0	—	35·7
Green salad	50·0	47·1	47·1
Cheese	30·0	10·7	10·7
Bread	50·0	14·0	14·0
	1700–1910	639·7	1088·8

Total quantity of water taken in food and drink in 24 hours:
Minimum = 3469·3 grms. Maximum = 5696·9 grms.

over, he had become considerably stouter; his girth had increased from 36 to 50 inches, and his weight from about 121 to 171·6 lbs. With this evident accumulation of fat, there was naturally considerable deposition on the heart also. As already mentioned, there was a hereditary disposition to corpulency.

Henceforward year by year the symptoms of a completely deranged circulation became more manifest, so that he could only attend to his practice by battling severely against his difficulties. To go into further details would be only a repetition of the symptoms described in the preceding pages, as his symptoms were exactly similar, in kind and severity.

CRITICAL ENQUIRY INTO THE POSSIBILITY OF TREATING CIRCULATORY DERANGEMENTS.

On surveying the above case, the question arises, What was the cause of this severe disturbance of the circulatory apparatus, intervening in so relatively short a time, after the balance afforded by a natural compensation had kept the patient on the whole in very fair health for thirty years?

Did the cause lie in the nature of the altered blood-distribution and the compensations connected therewith, so that they no longer sufficed after a certain time, or from alteration in themselves no longer maintained the balance; or did fresh injurious influences gradually arise which had hitherto escaped attention?

The first assumption, handy though it seems, is not very probable, for it is not evident why those compensations should have altered so very quickly, at the patient's age, and without the existence of any cardiac or pulmonary disease, or any exhausting illness: he had been perfectly well for fifteen years. It must be left altogether undecided whether there was absolute insufficiency of compensation or not, and the question had better be put thus: Were *those parts of the circulatory apparatus* which had effected the previous compensations *able or not to maintain the previous balance under altered conditions?* This question presupposes the possibility of altering the existing state of things, but not to commit its decision to *à priori* reasoning, excluding the actual invasion of the disease as far as possible, might be serious for the patient. Its answer must be

preceded by the practical experiment of *reproducing the earlier circulatory conditions*, and then the question becomes more theoretical and the difficulty will lie in the treatment. From this point of view, it will first of all be necessary to investigate the derangements which altered the early compensation, and then to venture the attempt to overcome these derangements, *i.e.* to re-establish the previous hydrostatic condition. It is easier to lay down than to carry out these propositions, and the possibility of their realisation will depend upon whether pathological destruction of the organs concerned has not advanced so far as to render a cure impossible ; in other words, whether we are not too late in our attempt to reproduce the earlier hydrostatic relations. We must bear in mind the possibility of the latter case.

On verifying the relations in question, we find in the patient's present condition two circumstances of extreme importance:

1. An *accumulation of blood, watery* from continual loss of albumen, in the pulmonary circulation and the systemic veins (which can no longer receive it without an injurious backward influence), and which can be overcome no longer by the heart.

2. A considerable degree of *corpulency* entailing fatty deposition in the thoracic and abdominal cavities, and therefore narrowing their space, and above all causing fatty heart. As regards the condition of the blood, it is important to decide whether this moderate stasis was simply due to the natural condition of things induced by the length of time, and the irregularities set going in the circulation, or whether external injurious influences operated mainly or subsidiarily in its production.

Now there is one striking feature about the case to help us in our decision. The patient's mode of life in his earlier years was very simple, and chiefly noticeable from the small quantity of fluids daily imbibed. Later on, while the solids remained much the same, there was a *sevenfold quantity of liquid taken daily*. All this amount must have passed into the circulation, and simple considerations of space teach us that if the previous compensations corrected to some extent the

derangement of the hydrostatic balance, and established an approximately normal state of things, *this balance must have been disturbed afresh* by such a sudden increase of the circulating fluid out of all proportion to the excretion. The lesser circulation, impeded by the compression of the lungs, was enabled by natural compensations to prevail so far over the afferent blood that no actual derangement occurred in the respiration or circulation; but when, instead of the previous quantity of fluid, which just corresponded to the capacity of the pulmonary circulation and was tolerated by it for fifteen or twenty years, exactly seven times as much was taken daily, the lungs could no longer dispose of the inflowing blood, which became dammed up in the right heart and the great veins of the systemic circulation. It now became a question how far the compensatory dilatation and hypertrophy of the heart could overcome the difficulty. It is evident that no considerable increase of these could occur. The maximum once overstepped, disorders would necessarily soon supervene, of the high grade already described.

But there is also another fact in the case, which we will discuss in a few lines, viz. *the fatty deposition on the heart* coincident with the general adiposity, and *the consequent lowering of its muscular capacity.* Assuming the ratio of the weight of the body to that of the blood to be 13 to 1 (which is not quite exact, however), with a body weight of 116 lbs. the blood weight was 9 lbs., but later on, when the body weight increased to 171·6 lbs., the blood weight was 13·2 lbs. While then, on the one hand, with general derangement of the hydrostatic condition a larger quantity of fluid than before was taken up by the pumping apparatus, and driven onward into a tubular system no longer proportionate to it, on the other hand the actual working capacity of the heart was lowered by the fatty deposition and infiltration, and the connected atrophy and partial degeneration of its fibres; it was thus no longer in a condition to make suitable energetic contractions, but could propel only a smaller quantity of blood under a lower pressure.

By the above exposition we have gained two points, firstly, a simple explanation of the fresh circulatory derangement which developed so rapidly, without being obliged to assume

advanced and irreparable degeneration under altered hydrostatic relations; and secondly, facts which will enable us to undertake the *reconstruction of the previous circulatory conditions*, as we have already done theoretically. This latter attempt is the only possible direct treatment of the disease as a circulatory disorder *per se*: if it miscarries we shall have to fall back on the treatment and amelioration of the separate symptoms (the usual treatment), without being able to exert any influence on the course of the disease itself.

It would be superfluous to discuss at great length the *means* at our disposal for working out a theoretical problem, supposing it possible to do so, which has never hitherto been solved. So much is certain, that pharmacological means and the treatment usually adopted are utterly powerless against the symptoms here portrayed. Even if the course of the disease can be stayed awhile by regulating the cardiac activity by digitalis, or by stimulating the kidney in increasing dropsy, &c., no distinct *improvement* is effected, nor is any alteration in the hydrostatic relations of the circulatory apparatus, nor any return to the previous condition attainable by medicinal means. Neither is the second problem to be solved by these means, i.e. the general fat-reduction (especially of the fat of the heart-muscle) with increase of cardiac functional capacity. Even the 'Banting' treatment, thoroughly carried out, is far too uncertain a method especially under the severe complications before us, and the fat-reduction (if obtained) and increased combustion effected by it will not save an organism already collapsing under severe circulatory derangement. The use of natural waters holding alkalies or iodine (Carlsbad, Marienbad, Krankenheil waters, &c.), by which at various resorts reduction of fat and lessening of weight are indeed attained, presupposes the integrity of the circulatory apparatus; otherwise the quantity of fluid ingested is no longer entirely excreted, and the disturbance of the hydrostatic balance between the pulmonary and aortic circulation is increased. I believe that the unfavourable consequences of these 'cures' rest chiefly on insufficient consideration of the circumstances. Almost without exception the previous symptoms of venous stasis, whether due to valvular failure, fatty heart, or other causes, become rapidly worse after the 'cur'

course, owing to the greater consumption of fluids, and thus the appearance or course of dropsy is hastened.

From the standpoint adopted by us, we shall make use of none of the above methods. The conditions are clear in themselves, and permit the division of the therapeutical problem into two parts, dealing respectively with

1. The quantity of fluid in the body, and the hydrostatic relations depending thereon.

2. The alterations in the respiratory and circulatory organs, together with accompanying disturbances elsewhere.

The first part of the problem contains the chief difficulty. If we can only fulfil the given indications, there will be compensation for the most part as far as concerns alterations of the organs indicated, and a more favourable result will be secured to our subsequent measures.

We shall therefore first of all try to bring about a retrogression of the circulatory diseases (so far as they depend on the amount of fluid in the body), and to preserve the restored hydrostatic balance with the previous compensations. This part of our problem contains these two indications, the one immediate (*Indicatio causalis*), the other a future one (*I. prophylactica*).

Our only chance of obtaining these results lies in *diminution of the fluids of the body.* Only by a marked diminution (adequate to the existing derangements) of the quantity of blood passing along the vessels will it be possible, on the one hand, for the pulmonary circulation to take up the quantity of blood flowing into it without derangement of the respiratory apparatus ; on the other hand, for the heart-muscle to overcome the blood-volume presented to it, and to be able to effect an equality between the arterial and the venous fulness. The causal indication answers this perfectly, and is the first condition of the restoration of the hydrostatic balance, and of any further therapeutic attempts.

The second condition, which directly follows from the first, is the preservation of the status obtained, or rather the *regulation* of the amount of fluid in the body, in order to prevent its re-accumulation and the renewal of the circulatory disorder. On the proper fulfilment of this condition depends

not only the circulatory condition, but the fate of the patient, and this indication, really a prophylactic one, entirely coincides with the first. It is clear that if we reduce the fluid of the body to its previous proportion, we have completely solved the problem in its main points, and we can then determine whether or not a balance of the morbid circulatory relations is possible under the previous compensations, whether the circulation can be carried on (the blood-volume remaining the same) in such a manner as not to threaten life, or else whether other factors, lying outside the hydrostatic relations, are alone the cause of the approaching and inevitable end.

Far more difficult is the second part of the task before us, viz. the treatment of the *pathological alterations in the organs of respiration and circulation*, caused by the circulatory derangements. This will depend upon whether we are able to render innocuous the tissue alterations that have caused destruction of an organ up to a certain degree, and to restrain the retrograde processes induced by these alterations from making further advance. There is no doubt that the first part of our task also is involved in this, and the re-establishment of the previous condition will only be thoroughly attained when the functional capacity of the affected organ, after elimination of the hydrostatic disorder, does not fall below a certain degree.

The organs of the respiratory and circulatory apparatus in question are in the first place the *blood* itself, which from persistent albuminuria and accumulation of water has lost its normal composition, and is watery and already disposed to dropsical transudations; next the *heart-muscle*, whose function is lowered by fatty deposition, and whose irregular action can no longer drive on the accumulated blood; then the *kidneys*, which are in a state of chronic hyperæmia, swelling, and inflammation, under the pressure of the venous stasis; and finally the *lungs*, whose vessels are much dilated and distended with blood, and whose interstitial tissue is hypertrophied, owing to excessive supply of nutritive material; while the respiratory space itself is diminished by the capillary ectasis, by the increase of the interstitial connective tissue, and by fatty accumulation on the heart and pericardium and other intrathoracic and abdominal organs, gaseous exchange being carried on only with difficulty.

For the treatment of these alterations, the following are the theoretical indications:

Diminution of the blood-volume, with increase of its albumen and general improvement; reduction of the cardiac fat and strengthening of the cardiac muscle, equalisation of the arterial and venous systems, unloading the kidneys and removal of their chronic hyperæmia and inflammation, unloading the pulmonary vessels (checking the hyperplasia of the interstitial connective tissue, reducing the ectatic alveolar capillary network, and increasing the breathing space), finally, removal of the fat deposited in the subcutaneous tissue and in the thoracic and abdominal cavities, and overcoming the tendency to excessive fat-formation generally.

The question now is, How closely will our giving effect to these indications correspond to our theory, and whether we are able so to follow the necessary indications as to perform the task before us. The work is doubtless one of the most difficult that can be proposed, but we may be sure of this, that without a satisfactory retrogression of these pathological alterations no decided improvement can be effected either in the circulatory derangement itself, or in any of the pathological processes depending on it. We must at any rate try and act, even though by unusual methods, upon the indications clearly laid down in the foregoing theoretical considerations.

The method which I proposed to myself, and which seemed most appropriate for attacking, with the sharpness of a physiological experiment, the derangement of the circulatory apparatus and the consecutive processes, rested on principles already contained in the problem above stated; and it can be detailed with the utmost precision.

THE PROBLEMS TO BE SOLVED IN A TREATMENT OF CIRCULATORY DERANGEMENTS.

I. Different Measures for Reducing the Fluids accumulated in the Body, and the Hydrostatic Conditions depending thereon.

The first part of the problem requires:

a. Diminution of the fluids of the body in general, and

in particular unloading the pulmonary circulation and venous system, facilitating the work of the heart, and relieving the kidney.

b. Regulation of the fluids of the body, to effect a permanent balance between the arterial and venous blood-volumes.

A. The simplest way of reducing the body fluids would be to take directly from the veins as much blood as might be thought necessary for the removal of the symptoms of stagnation. But considerations are opposed to this, too important to allow us to expect a lasting effect from it. In the first place, we cannot *à priori* determine how much blood should be taken, and it is not a matter of indifference under the circumstances whether too much or too little be drawn (especially when we consider that subsequently the watery character of the blood is itself the object of treatment). Moreover, there would be considerable loss of the solids, the corpuscles, albumen, and fibrin. But chiefly, its volume, even if lessened in this way, would soon be increased again by the fluids of the tissues, and by absorption from the intestinal tract; we should only have altered its volume and made it poorer in solids. And lastly, experience of venesection in dropsy due to circulatory disease leads to its rejection. The pressing indication to make the blood richer in solids, *i.e.* to make it thicker, must be carefully kept in view, and every loss of albumen and corpuscles is to be carefully avoided.

Our problem will be better stated perhaps if we substitute the term water for the term fluids, and aim at reducing the *water* of the body till the blood is so reduced in volume that the stagnation is removed, and the heart is able to do its work again.

The only means of thoroughly carrying out such a removal of water from the body consists in an *energetic increase of the watery excretions*, and an equally thorough *diminution of the supply of fluids* to the system; so that the loss from the skin, lungs, and kidneys will no longer be covered by absorption from the stomach and intestines, and the excess accumulated in the body will be drawn partly into the vessels, partly into the tissues, for normal consumption.

Unfortunately we are not in a position to increase the water-

excretion from all the organs which normally excrete water, and least of all can we obtain a persistent increase of the renal excretion by diuretics. Apart from this, however, the kidneys are under abnormal pressure, and show signs of chronic hyperæmia and inflammation, so that to act on them medicinally would be to increase their function, and to cause symptoms of secondary irritation. On the contrary, the indication here is to unload them of the blood-pressure they are under as soon as possible, if we wish to prevent the advanced stasis from leading to incurable destruction. There remains therefore only the skin and lungs by which to bring about an increased water-excretion from the body.

Here again our measures will not be altogether pharmacological, for we possess no drug that can cause a persistent increase of the excretion of water from the lungs; on the other hand, many diaphoretic means for obtaining increased sweating (*e.g.* pilocarpine) cause results which are often undesirable at the time, perhaps to be specially avoided. Moreover the use of diaphoretics is always attended with the introduction of a large supply of fluid to the body, so that it really becomes a question whether the copious sweating balances this addition; of the stored up fluids of the body little or none is removed. We therefore turn to those methods which in a *physical* manner, by the influence of *heat* upon the body, or else by *increased muscular activity* (as in exercises, *long walks*, *ascents*, and, in short, *mountain climbing*), induce an increased water-excretion from the skin and lungs, by powerful and persistent excitation of the sweat-nerves, and forced respiration. The former influence is exerted especially by hot-air baths (*Turkish baths*), which I have tried satisfactorily on several patients in whom the respiration was unhindered. Next come various other baths, vapour baths when they can be borne, packing, enveloping in woollen or caoutchouc coverings, to obtain congestion of the skin and increased sweating.

On the other hand we must bring the *dietetics* into immediate connection with these physical procedures. With increased excretion of water we shall only obtain a diminution of the blood accumulated in the body, when the amount imbibed is not merely kept at the previous level but diminished, and the

dehydration of the body will be quicker and more energetic the smaller the amount of water supplied. The patient's diet must, therefore, undergo a thorough rearrangement. Whilst we should promote the addition of albumen to the body, in order both to cover the continual loss by albuminuria and to facilitate the speedy combustion of the *stored-up fat* by an appropriate diet rich in proteids, we must reduce to a minimum not only the patient's drink, but even the fluid portion of the solid food.

Deprivation of fluids, as far as the tissue-changes permit, will form the leading principle of this part of our treatment. The amount of water in the blood and tissue is already so great, owing to the disease, that if the fluid supply from without be lowered, the amount necessary for the physiological processes of the body can be drawn from this excess within it. In fact, a satisfactory reduction of the body fluids is only to be obtained when they are thus drawn upon for physiological use, at the same time that the fluid excretions are increased.

A *measure* of the dehydration may be found in the solubility of uric acid and its salts in the freshly-voided urine, the fluid supply being lowered to the minimum which the patient can tolerate, as long as the urine is clear when passed, and only deposits on cooling. The precipitation of urates and formation of concretions within the body are thus rendered impossible.

By a water removal thus instituted and persistently kept up, the solution of this part of the problem at any rate will be obtained.

B. Secondly, we must seek to effect the same purely physical influence on the hydrostatic relations of the circulatory apparatus, if the results obtained are not to be lost directly. The fluids of the body being reduced to the necessary minimum by the above methods, everything depends on our *maintaining* a steady balance between the arterial and venous circulations, lest by a greater water supply to the blood we induce the old stagnation in the venous system.

The means here proper for *regulating* the body fluids are the same as those for their reduction, and the method will only be modified in so far that no further dehydration of the body will be caused, but the level once obtained will be kept up.

The previous efforts to obtain increased sweating will be

either omitted for a long time, or only partially carried out—partly to oppose any accumulation of large quantities of fluid in the body, especially when more is taken in hot weather, partly to cause unloading of the kidneys by maintaining a flow to the skin. The patient, therefore, must take long walks regularly every day, wherever his avocation may lead him; but besides this, trying expeditions, walking for many hours at a time, ascents of elevations, &c., must be performed with the same indications, because we can hardly expect to be certain at first that the fluids taken are all perfectly excreted. The supply of fluid nourishment, and drinks especially, must always remain a limited one, subjected to constant control, and that proportion must be adhered to which previous experiments have shown to be the *minimum* necessary for the tissue-changes of the body.

Whilst in the above regimen it was not difficult to fix the points beyond which it would not be safe to carry the dehydration of the body, far greater difficulties beset the determination of the amount of fluid which can be taken without any injurious influence on the hydrostatic balance, and will all be excreted. In general, after perfect reduction of the body fluids we must endeavour to restrict the fluid supply to the smallest possible amount, and if this be overstepped at times we must again regulate it by further deprivation and by increasing cutaneous transudation. We all drink far too much, and even the amount established as normal is considerably in excess of the quantity absolutely necessary for tissue-change. The desire for fluids is not regulated by the need of the body for water, nor even proportional to it, but almost always exceeds this enormously. Even after great loss of water, as after long marches or in very hot weather, far more is taken than is required to cover the recent loss. As a rule, the pleasurable sensation connected with the act of drinking is alone answerable for this excess, and the feeling of thirst is often due only to habit. This feeling is lessened directly the body is accustomed to less fluid, and may be got rid of altogether by taking extremely little.

As to the duration of the above regimen, no fixed time can be given, but the proportion of fluid once fixed upon as necessary for the regulation of the body fluids must be adhered to

more or less closely all through life, for every time this proportion is exceeded there will be an increase of the fluids in the tissues, and the continual repetition of even a small excess will give occasion for fresh stasis in the circulation, with its well-known consequences. The patient's lot is not so hard as might be at first imagined, for if the body is once accustomed to a small definite quantity, sufficient for its physiological functions, there is no longer a desire for excess, and even if there be increased thirst from increased excretion of water, the excess taken then will only correspond to the excess of excretion, unless the patient intentionally drink beyond the feeling of satisfaction. Small transgressions are easily corrected by the methods above given.

II. Methods of Treating the Alterations in the Different Organs, caused by the Circulatory Derangement.

In the second place, the alterations in the respiratory and circulatory organs, and the disorders elsewhere connected therewith, so far as they are capable of retrogression, come under treatment.

1. THE BLOOD.

The most important part of the circulatory apparatus, and at the same time the connecting link between the various organs sharing in the morbid process, is the blood itself. And it demands a careful consideration.

It has been seen in the preceding pages that the idea of effecting the necessary reduction in the volume of blood by venesection must be rejected, because such an unloading of the circulation can only happen at the expense of the deterioration of the blood, inasmuch as a portion of its solids, the albumen and corpuscles, is lost entirely thereby. The chief alteration which the blood has undergone is *increase of its water*, in consequence of the lessened water-excretion, the increased fluid supply, and the continuous loss of albumen in the urine; and it depends chiefly on the possibility of restoring the blood to its normal consistency, whether a lasting improvement can be effected or not. Apart from the anomalies of nutrition, the

circulatory disorders standing in direct relation to one another, viz. the stasis in the veins generally, in the pulmonary circulation, and in the kidneys (with the dropsy and albuminuria), are directly dependent on the proportion and watery consistency of the blood. Besides the immediate *diminution* of its volume, therefore, the *concentration* of the blood must be regarded as a very important part of our problem.

By the method which we have given for the reduction of the fluids of the body, we have already at hand the means of effecting this alteration most energetically and in the only possible manner. By this procedure the blood is compelled to part with a portion of its water, owing to the increased water-excretion from the skin and the diminished supply of water in the food and drink; and though this loss is partly covered at first by an increased flow of water from the tissues into the blood, and by the absorption of serous transudations, on persisting with the method these sources will no longer ultimately suffice to balance the amount used up in tissue change and lost in transpiration. In a short time the blood must yield up its water permanently, and it is then not only *lessened in volume*, but its *solids are increased*, viz. its albumen and hæmoglobin.

Since in the derangements before us the blood loses albumen, not only by the amount expended in tissue-change, but by its excretion in the urine (as long as the stasis and hyperæmia of the kidneys go on, apart from any tissue-alterations in these organs), and quickly undergoes a diminution of this constituent, so besides the removal of water *a good supply of food rich in albumen* is an unavoidable condition for the success of the whole method.

2. THE LUNGS.

So far as the pulmonary alterations are amenable to treatment, and do not depend on an anatomical destructiou beyond the reach of any method whatever, we must distinguish between those due to compression and those induced by stasis aud hyperæmia. The effect of both upon the lungs is to cause diminution of the respiratory space, serous infiltration of the parenchyma, and alveolar catarrh (Friedreich, Bamberger,

Zucker, Colberg [1]), and our first task will be to overcome these conditions. The acute and chronic catarrhs which have arisen in the lungs and air-passages come under secondary consideration, while the thickening due to increase of connective tissue does not come under treatment at all.

Owing to the fatty deposition on the pericardium and heart itself, and the upward pressure of the diaphragm in consequence of accumulation of fat in the abdomen, and distension of the stomach and intestines by a copious fluid diet, there is advancing compression and respiratory insufficiency of alveolar tracts, which, though but small, are of considerable importance when the respiratory space is so limited. Moreover, in consequence of the high vascular tension, which acts with greater effect, owing to the vascular dilatation, pressure is exerted against the respiratory surface, and the capacity of the alveoli is diminished. The latter, having become thus partly atalectic, are still capable of being distended under a higher pressure of air, and after death can be in part blown up by a tube, when the dark brown spots can be seen to take on a redder tint. They are, therefore, free to expand during life if the pressure upon them be removed and the hindrances to their expansion overcome.

The compression induced by fatty deposition will cease when we bring about the absorption and combustion of the fat, and the diminution of the breathing space will be corrected by reducing the volume of the blood, and unloading the overcharged lungs. On the other hand, the retrogression of the alveolar ectases already mentioned as accompanying 'brown induration' (which finally causes obliteration of pulmonary tissue), is at once facilitated by reducing the blood and unloading the pulmonary vessels, and even if perfect expansion of alveoli with ectatic capillaries is not obtained, nevertheless larger or smaller tracts of lung tissue will be reclaimed.

The means by which we may effect a sufficient inspiratory expansion of more or less impermeable alveoli will be necessarily purely mechanical, as the conditions before us show, and the same energy and persistency will be required in their application as in the methods adopted for the removal of water from the body.

[1] Colberg, 'Beiträge zur normalen u. pathologischen Anatomie der Lungen,' *Arch. f. klin. Med.*, vol. ii. p. 483.

Two methods are here feasible, one of which almost exactly coincides with that given for the solution of the first problem, and which I have exclusively employed in the cases met with by me, while the other will be equally successful in cases where the conditions fail for carrying out the first.

To cause increased water-excretion by the skin we may order persistent *exercise*, which always quickens the respiration, but very soon causes want of breath. If the locomotion be extended till the patient ascends elevations or mountains, not only is there a great increase of sweating, but the patient soon breathes only by summoning all the means at his command. He is obliged to stop every ten or twelve steps. The frequent and loudly audible respirations begin with *long-drawn and deep inspirations*, with spasmodic contraction of the diaphragm, and the patient supports himself against some fixed object, his alpenstock *e.g.*, the pectoral muscles labouring hard and the ribs being raised by the intercostals. The expiration, on the other hand, is but short, and is quickly followed by the long-drawn inspiration. The same thing occurs every fifteen or twenty steps, without any diminution in the intensity of the respiratory movements, and the exertion can go on for hours with but slight interruption. But by exercise the respiratory muscles, like any other muscles, undergo a great increase of their functional capacity. It is, therefore, possible to allow the respiratory movements necessary for the expansion of the lungs, to be continued for the necessary period without fear of injuring the patient, or of lack of necessary energy and perseverance.

Under such a powerful inspiratory expansion of the thorax, we may assume that the air passing in under the ordinary atmospheric pressure is sufficient to overcome the elasticity of the lungs, and with it the opposition of the alveolar walls (previously compressed, ectatic, and collapsed) against inspiratory distension, and thereby to facilitate gaseous exchange.

The duration of the treatment should be several years, if we desire a condition at all stable, and the respiratory 'gymnastic' must always be kept up, in a more restricted sense, in order to preserve the freshly-gained expansion and breathing capacity of the lungs.

Where it is impossible to effect in this way the expansion of insufficient alveoli, *the inspiration of compressed air* is to be carried out under the rules of respiratory therapeutics. The main difficulty of this treatment lies in keeping in view the fact that the degree of inspiratory expansion of the thorax and lungs, and the intra-pulmonary blood-pressure, do not regulate themselves as in the foregoing methods by reduction of the blood-volume, but the degree of atmospheric pressure to be applied must be accurately determined, and the diminution of the body-fluids must *precede* the mechanical dilatation. The inspiration of compressed air will begin, then, only after six or eight weeks' energetic removal of water; and even then with only an excess of $\frac{1}{100}$ atmosphere, the pressure very gradually rising to $\frac{1}{80}$ atmosphere, and finally to $\frac{1}{60}$, very rarely reaching $\frac{1}{40}$. The sittings must be repeated four to six times a day, and should be not less than half an hour long, if they are to effect anything like the energetic and persistent inspiratory expansion by forced muscular action caused by three or four hours of mountain climbing. Where soon afterwards or later on it is possible to undertake mountain tours as well, they should be supplemented by the pneumatic treatment on the days of rest, or else the latter must be repeated after a few months. The course of exercise, to be detailed later on, must be continued for five or six weeks at a time for several years.

3. BRONCHI.

Finally, as regards the hyperæmia and serous infiltration of the lung-parenchyma and bronchial mucous membrane connected with the circulatory derangement, and the frequent acute catarrhs with abundant exudation arising upon slight irritation, the treatment coincides altogether with that for the removal of the stasis, and they will be overcome when this is removed. The intercurrent catarrhs require only a symptomatic treatment, according to the general rules in such cases. The *indicatio causalis* of the whole affection can only be met by reduction of the body-fluids.

4. HEART AND VASCULAR APPARATUS.

There are two indications as to the heart: first, reduction of its fat with that of the body generally; and second, strengthening its muscle, with restoration of the previous compensatory hypertrophy.

In the treatment of the symptoms before us we move in a circle, inasmuch as the disorders arise out of and react upon each other.

Owing to the incomplete arterial filling and the watery character of the blood caused by stasis there is necessarily a lowering of the oxidation processes in the body and of the combustion of carbohydrates, so that, as in other cases of similar alteration of the blood (chlorosis, &c.), there is excessive development of fat, especially when there is a natural predisposition thereto, and when an excess of carbohydrates is taken in the food. Just so, from incomplete filling of the coronary arteries, nutritive derangements gradually arise in the heart-muscle, owing to which, and to the want of sufficient oxygen, it is no longer able to perform the increased labour demanded of it, and gradually retrograde metamorphosis affects more or less of its fibres. Hence it happens that by fatty deposition on its surface, and by conversion of more or less of the intermuscular connective tissue into fatty tissue, its working power is lowered, and the disorders in the circulation are still further increased.

The *indications* are accordingly the same as those for the circulatory derangement in general—reduction of the fluid supply, removal of water from the body, thickening the blood, (lessening its volume and making the heart's action easier), removal of the venous stasis, greater arterial filling, increased oxygen-supply, and finally, *increased nutrition and working power of the heart-muscle*, with the consequent influence of all this on the circulation generally.

The *means* are accordingly the same as those for the reduction of the body-fluids, viz. increased excretion of water from the skin, and lessened supply of water in the food and drink; and we may apply for the removal of fat those methods selected for the removal of water, or rather their application will have this twofold action.

But having made it our task to increase the combustion of the fat deposited in the body, we must also lower its supply as much as possible, and withhold from the patient foods which are rich in fat and carbohydrates. On the other hand, an increased supply of food rich in nitrogen is necessary in these and similar cases, for this reason amongst others, that the blood has become absolutely poorer in albuminates, owing to the long-existing circulatory disease, and this loss must be covered by a *sufficiently nitrogenous diet.*

Especial attention is demanded by the *exhaustion of the heart-muscle* and consequent death, in kypho-scoliosis with hypertrophy of the right ventricle. We have seen, as the cause of this, the ever-increasing flow of blood to the right heart, and the increased intracardial pressure, which from the long duration and the imbibition of too much fluid increases at last to a degree which the heart cannot surmount, while the formation of oxyhæmoglobin steadily declines, and the cardiac energy is lowered by the accumulation of carbonic acid in the blood. The removal of the danger of more or less sudden paralysis of the cardiac nervous system (the part affected, for, as we have said, the muscular structure is in such cases perfectly normal) is only to be expected by removing from the heart the above causes, acting mainly mechanically, *i.e. lowering the intracardial pressure by lessening the blood-volume.* On grounds already given, we can do this only by a speedy removal of water from the blood (by lessening the fluid-supply and increasing the fluid-excretion), not by any sudden depletion, as by venesection.

Finally, we have yet to consider the *strengthening of the heart-muscle*, and the balance between the arterial and nervous systems, where cardiac debility has resulted from *fatty deposition*, *fatty degeneration*, and *atrophy*, or where a *lost compensation* is to be re-established.

How this is to be effected will be explained in our investigation of the means at our disposal for acting on the heart and vascular apparatus.

5. KIDNEYS.

The renal alterations developing under the influence of chronic hyperæmia are only amenable to treatment in so far as

the *stasis* and hyperæmia may be diminished by a diminution of the blood generally, and the *venous pressure* in the kidneys be *lowered* by this and by universal arterial filling. Indirectly, also, the overgrowth of connective tissue in the parenchyma, the passage of albumen into the tubules, and the alterations going on in the epithelium will be favourably influenced when, by the reduction of the blood, the quantity of nutritive fluid bathing the renal parenchyma is lessened, and the stagnating blood is quickened in the veins.

The improvement going on in the kidneys when the venous pressure is lowered is not easy to observe; a standstill or retrogression of the pathological alterations is here far more difficult of recognition, and takes a longer time, which cannot be settled *à priori*, before it makes itself felt under the influence of totally altered circulatory conditions, than is the case in other organs, where subjective improvement and physical investigation give us important data for the estimation of any alterations that have occurred.

Experience has taught me that if any influence is to be exerted on the kidneys by altering their hydrostatic relations, a long period of time and an exact and constant regulation of the fluids of the body are necessary before the urine becomes normal as to quantity and quality, and before the albuminuria is cured. In this respect I must refer the reader to the second part of the work ('Clinical Histories') for the influence of reduction and thickening of the blood upon the pathological processes in the kidneys.

Dropsy.

It would seem at first sight as if the first direct effect of concentration of the blood would be a backward flow of fluid from the tissues into the vessels and a rapid subsidence of dropsical effusions, especially as there is another physical factor here, usually considered of great importance, viz. the lessened blood-pressure in the veins as soon as the body-fluids are reduced to a certain degree, and the stasis in the pulmonary circulation and great venous trunks has been relieved. But reflection teaches that the case is otherwise, and a long period, half to one year even in favourable cases, may be necessary be-

fore the last traces of œdema will have disappeared. We have to bear in mind the condition of the vessels which have suffered derangements of nutrition for many years from the watery character of the blood, and in the walls of which alterations have occurred which facilitate an abundant exudation of watery serum. Cohnheim has shown that injections of one or two litres of watery serum can be made into the veins of an animal without causing an exit of fluid into the subcutaneous tissue; but that if the *nutrition of the vessels* has suffered from a watery condition of the blood, a slight increase of intravascular pressure is enough to produce watery exudations in the tissues. Finally, we must bear in mind that though there may be only a trace of albuminuria, or for many months none at all, the previous excess of water in the blood is not perfectly got rid of, but persists more or less as long as there is no accurate regulation of the fluid supply, and no sufficient supply of albumen.

So, too, everything must be avoided which may lessen the quantity of albumen in the blood, as, for instance, an unfitting diet, and especially all therapeutic procedures which cause a more watery consistency of the blood. These were the leading ideas which induced me not to try and unload the veins by drawing blood, but to effect its concentration by increasing the water-excretion from the skin and lungs, and by lessening the supply of water to the system. Only when there is no longer time for this, and the stasis in the lungs threatens the respiration by the development of secondary processes, extensive capillary bronchitis, and commencing pulmonary œdema, may we remove more or less blood from the body by opening a vein, until things are equalised and the circulation and respiration are again free. But in such cases it is all the more necessary that the patient should be prevented from replacing by imbibition the water that he has lost by venesection. The deprivation of water and the supply of albumen must be the more energetic since the blood is poorer in albumen by the above procedure. The further treatment will perfectly coincide with that which we have adopted in cases where no great removal of blood has occurred, and will only be modified in so far as the secondary processes in the lungs and bronchi may indicate. I have not had occasion to treat such a case myself, but according to my

experience so far I should adopt the same method, if I were only sure of being able to carry it out.

With the above exposition we have endeavoured to unfold the task before us in its separate indications. But before we go any further we must occupy ourselves with an examination of those means and methods by which we hope to effect—

1. A reduction in the quantity of fluid in the body.
2. An oxidation of the accumulated fat, a fat-reduction.
3. A balance between the arterial and venous systems.
4. The strengthening of the heart-muscle; and
5. The cure of the secondary renal affections, as far as is possible.

It is self-evident that this examination can only be carried out by a corresponding series of *experimental investigations*, from the results of which we may obtain at once a *foundation* and a *standard* for our succeeding therapeutical procedure.

A. *EXPERIMENTAL INVESTIGATIONS ON THE EXCRETION OF WATER FROM THE SKIN AND LUNGS.*

The watery excretions which take place through the skin and lungs are not insignificant normally, and may be very much increased by favouring the conditions which influence them. As nature at times makes use of them to remove from the body large quantities of water taken into it, more quickly than by the kidneys alone, so, when the latter are deranged in their functions, we always endeavour to favour the excretion of a pathologically acting quantity of water by the former.

If, as in the cases before us, we would make a similar attempt in circulatory disorders, severe venous stasis and accumulation of water in the body, we must above all keep before our eyes the way in which these organs act; and we must remember that the excretion of water by the skin is due to the activity of glandular organs, subject to definite physiological laws like other glands, while loss of water from the lungs is to be looked upon as a simple process of diffusion and evaporation, dependent only on physical conditions.

I. ON THE EXCRETION OF WATER BY THE SKIN.

The sweat-glands must be regarded as the organs which effect the excretion of water by the skin. They are found in various sizes and numbers on different parts, and hence the difference of perspiration in different places, the face, forehead, palms, and soles. According to Krause's figures,[1] in which the larger sudoriferous glands are reckoned equal to two, three, or four smaller glands, and the smaller are coupled

[1] Krause, art. in Dr. Wagner's *Handwörterb.*, vol. ii. p. 108.

together to form one gland, there are in round numbers on every square inch of surface of the palm of the hand or sole of the foot 2,700, of the back of the hand 1,500, and of the forehead and neck 1,300; while Wilson[1] counted 3,528 and 2,268 glandular openings on a square inch of the palm and sole respectively. Krause reckons over two millions for the whole skin (but even this estimate is too small according to the latest investigations), and estimates the whole surface of evaporation at 38 square centimetres, a surface far too small for all the evaporation which occurs.

According to these anatomical results we should be in error if we drew any conclusion as to the sweat-production of the whole body from the result of the secretory activity of any one part of it by a process of multiplication. Unfortunately Funke's[2] first investigations were made in this way, and apart from other sources of failure we should be making a great mistake if we took his figures as a guide in our therapeutic procedures for removing water from the body by increased sweating.

In Funke's experiments the skin of the forearm served as the secretory surface. The amount of sweat excreted by this surface in an hour varied much in different persons under the same external conditions, and again in the same persons under different conditions of temperature and bodily effort. By multiplication of the hourly value found for the arm, under the different conditions of total rest, moderate exercise, and energetic exertion in the sun, the figures he obtained for the whole body were 74·749 to 818·491 grammes. Let us suppose with Funke that the intense excretion represented by the latter figures could go on for twenty-four hours, then the body would lose more than 19 kilos. (nearly 42 lbs.) of its weight by the skin, while on the lowest estimate the loss of weight would be 1793·9 grammes (4 lbs.)

Seguin[3] put the whole body except the head into an air-

[1] Wilson, *On the Management of the Skin.* London, 1847.

[2] O. Funke, *Lehrbuch der Physiologie*, 6th edit., by Dr. A. Grünhagen, vol. i. p. 396. Leipzig, 1876.

[3] Seguin, *Mém. de l'Académie de Paris*, 1789 and 1790, and *Annal. de Chim.*, vol. xc. pp. 52, 413.

tight covering, and determined the amount of sweat excreted in a given time from the surface of the body, or rather the fluid portion alone of the sweat. Here the secretion was eventually altered by the air-tight seclusion of the body. We cannot therefore accept as normal the figures given by him as representing the daily excretion from the skin, viz. 917·8 grammes (2 lbs.), or $\frac{1}{64}$ of the body-weight, double the amount excreted from the lungs according to this author.[1]

V. Weyrich[2] determined the dew-point of the air contained in a bell, by means of a Daniell-Regnault hygrometer, and calculated from this the tension of the watery vapour suspended in it, and hence the amount of water. According to this method (and by the use of assumptions not too well founded) W. Weyrich estimates the daily water-excretion from the skin at about 560 grammes (nearly 20 oz.)[3]

Quite recently Röhrig[4] has estimated from numerous experiments the carbonic acid excretion from the surface of the body, under ordinary conditions, at 14·076 grammes for the twenty-four hours, and the sweat at about 634·44 grammes. According to this observer the excretion of water and of carbonic acid varies much with the surrounding temperature. He further states that Favre excreted 166 grammes from the skin in an hour, and that in the 'sweating treatment' as much as 800 grammes have passed into the clothes around the patient within an hour or an hour and a half.

Finally, glancing at the observations of practical experi-

[1] We ought to mention the older observations of Sanctorius (1594), and of Rye (Rogers' *Essay on Epidemic Diseases*, Dublin, 1834). Rye determined only the total loss by the skin and lungs together; if we take Seguin's estimate of their excretions, viz. 2 : 1, the average daily loss by the skin would be 1,037 grammes. The relation of the daily perspiration to the body-weight is, according to Rye, 1 : 85, to Seguin about 1 : 67. Valentin repeated Seguin's experiments (*Repert. f. Anat. u. Physiol.*, vol. viii. p. 389), and found the relation of the skin loss to the pulmonary loss somewhat smaller than Seguin's, viz. 3 : 2.

[2] V. Weyrich, *Die unmerkliche Wasserverdunstung der menschl. Haut.* Leipzig, 1862.

[3] W. Weyrich, *Beobachtungen über die unmerkliche Wasserausscheidung der Lungen und ihr Verhältniss zur Hautperspiration.* Dorpat, 1865.

[4] Röhrig, *Physiologie der Haut*, Berlin, 1876. Compare Winternitz, 'Hydrotherapie,' in V. Ziemssen's *Handb. d. allg. Therapie*, vol. ii. part iii. p. 148 (Translated by Dr. Elsner—Smith Elder & Co.)

menters, Wigand states that he lost 812·5 grammes in a vapour bath of 110° to 117° F.; Berthold lost 750 grammes within thirty minutes; and Lemonier lost 630 grammes in eight minutes after a bath at 113° F. In the experiments instituted in Professor Manassein's wards on the physiological action of the Russian vapour bath, the loss of body-weight during a bath lasting from half an hour to two hours was between a minimum of 100 grammes and a maximum of 900 grammes.

On considering all the above estimates of the amount of water excreted by the skin and in part by the lungs in a definite time, we find considerable differences both in the results obtained from physiology and those observed by practical experimenters. The cause of these discrepancies lies partly in the nature of the experiments, in making deductions from one particular region of the body to the whole of it without reference to the different distribution of the sweat-glands; and partly in reckoning the twenty-four hours' excretion by multiplication of the quantity excreted in a given time, and thus assuming that the glands could act with the same intensity during all that time. Moreover, by air-tight inclosure of part or the whole of the skin, by warmth, and by exercise, a number of influences are in operation to which the skin reacts with increased vigour. If we assumed, with Krause and Meissner, that the whole surface of the body (estimated by the former at 15 Paris square feet) evaporated water, instead of a surface of glandular apertures of about 38 square centimetres, then more reasonable figures than hitherto would be obtained both theoretically and practically, since on this assumption the production of sweat is to be regarded for the most part as a simple physical process. For the number of sweat-glands would cease to have any importance in relation to the body-surface, and we could easily establish the physical conditions under which a skin surface of n square centimètres must evaporate x grammes of sweat. But we must look upon the excretion of water by the skin in sweating, especially since the thorough investigations of Goltz,[1] Kendall,[2] Luchsinger, and

[1] Goltz, *Arch. f. d. ges. Physiol.*, xi. pp. 71, 72, 1875.

[2] Kendall and Luchsinger, *Arch. f. d. ges. Phys.*, xiii. p. 212, 1876; and Luch-

others, as a *true secretion*, induced by nervous irritation, and the activity of the gland-cells must be regarded as a direct result of nervous excitation. As Luchsinger has shown, by far the greater number of conditions which influence the perspiration *act exclusively through the nervous system*, and its occurrence is evidently a 'central' phenomenon according to known analogies. In particular, every agent that excites the spinal cord appears to influence sweating.

If we consider the excitations which alone interest us here, we have already repeatedly insisted on the important influence of *dyspnœa* and of *muscular activity* on the sweat-secretion, especially when connected with severe venous stasis. Of the remaining sensory irritants which we can employ, *warmth* is an eminently practical means of provoking sweat reflectorially (Luchsinger); while *pilocarpine*, which is equally available, belongs to a small group of substances which act peripherally and powerfully upon the sweat-glands, even when they are cut off from the central nervous system (Luchsinger,[1] Nawrocki,[2] Marmé[3]).

The amount of sweat secreted after injections of pilocarpine is very large, and the individual excitability of the sweat-nerves, the watery condition of the blood, and other causes not yet ascertained, influence this amount, apart from the quantity of the drug injected.

Thus Weber[4] observed on an average a loss of weight of two kilos. after two to three hours' sweating, on one occasion as much as four kilos.; while Bardenhewer[5] gives 500 to 700 c.cm., and Lösch 500 to 600 c.cm., as the average loss. Curschmann[6] observed an excretion of 1,000 to 2,000 c.cm., on one occasion 2,500 c.cm. Sasezki,[7] on increasing the dose from

singer, 'Die Schweissabsonderung,' in L. Hermann's *Handb. d. Physiol.*, vol. v. part i. p. 421, Leipzig, 1880.

[1] Luchsinger, *Art. f. d. ges. Phys.*, xv. p. 482, 1877.

[2] Nawrocki, *Centralbl. f. d. med. Wissensch.*, 1878, No. 6.

[3] Marmé, *Göttinger Nachrichten*, 1878, p. 106.

[4] Weber, 'Ueber die Wirkung des Pilocarp. mur.,' *Centralbl.*, 1876, No. 44.

[5] Bardenhewer, 'Indication des Pilocarpins,' *Berl. klin. Wochenschr.*, 1877, p. 7.

[6] H. Curschmann, *Berl. klin. Wochenschr.*, No. 25, p. 383.

[7] Sasezki, 'Beiträge zum klin. Gebrauch des Pilocarp. mur.' Aus der Klinik von Prof. Manassein. *St. Petersb. med. Wochenschr.*, 1879, No. 6.

$\frac{1}{8}$ to $\frac{1}{2}$ gramme, in comparative investigations, obtained 80 to 100 grammes of sweat, and finally Lewin[1] noted in forty experiments an average loss of water of 350 to 400 grammes from the skin and lungs.

Besides the sweat-secretion, the *salivary secretion* also undergoes such a proportionate increase that, inasmuch as we are treating of a general increase of the water-excretions of the body, we must give it further notice.

According to Scotti, the salivary flow after a pilocarpine injection[2] is from $\frac{1}{4}$ to $\frac{3}{4}$ litre. Curschmann[3] obtained, after injections of 0·002 gramme in ten people, 102 to 484, on an average 275 c.cm.; and after 0·003 gramme, 256 to 600 grammes of saliva. Lewin's figures[4] vary between 130 and 360 grammes after injections of 0·015 gramme of pilocarpine, and between 220 and 500 grammes after 0·002 gramme. It may be mentioned that Lewin did not observe any diuretic action of pilocarpine, as had been stated by others.[5]

Of essential importance for the increase of sweat is a rich supply of arterial blood to the sweat-glands, with lowered arterial tension and greater capillary fulness, conditions which, as we shall presently see, are induced to an extraordinary degree by the powerful muscular exertion and heightened cardiac activity which attend *mountain-ascents*. Moreover, in cases of circulatory derangement, the excess of water in the blood greatly assists the separation of sweat from the body. Finally, our therapeutic aim in particular requires us to keep in mind that whatever excitation be used, the excitability of the sweat-glands diminishes with their long activity; and hence the preceding estimates lose all meaning if extended over the whole twenty-four hours.

II. THE EXCRETION OF WATER BY THE LUNGS.

As already stated, this excretion occurs partly by diffusion of gases, partly by evaporation, and therefore for the most part

[1] Lewin, Aus der Klinik für Syphilis. 'Ueber die Wirkung des Pilocarpins im Allgem.,' *Charité-Annalen*, V. Jahrgang, 1880.

[2] Scotti, *Berl. klin. Wochenschr.*, No. 25, p. 383.

[3] Curschmann. Vide sup. [4] Sasczki. Vide sup. [5] Lewin. Vide sup.

is subjected to the laws underlying these purely *physical* processes.

Since in the lungs a portion of the water of the blood is continually evaporating, in accordance with the pressure of the air upon the capillaries (viz. one atmosphere) and the temperature of the blood, and thus *passes into vapour continually* from the moist surface of the respiratory mucous membrane, the air in the respiratory passages is kept almost saturated, and the inspired air, according to its warmth and dryness, can thus remove more or less water from the body. Now expired air has a pretty constant high temperature, only very little influenced by the variations of temperature of the outer air, and therefore it will contain more aqueous vapour than the latter.

According to Valentin and Brunner,[1] who made most accurate observations on the temperature of respired air, when the external temperature is—

From 59° to 68° F.,	the former is	99·1° F.
At 20·6° F.	„	85·6° F.
At 107° F.	„	100·5° F.

According to Weyrich—

At 62·6° to 66° F.	„	97° to 98·6° F.
And at 111·2° F.	„	100·5° F.

But the water given out will undergo considerable variation in quantity owing to the respiratory mechanism, according as the respirations are slower and deeper, or quicker and more superficial: in the former case not only does more air leave the lungs, but it holds more water than in the latter, where the percentage amount of water in the expired air sinks considerably.

The evaporating surface of the lungs corresponds to the depth of the respiration and the amount of air expired. The excretion of water from the lungs accordingly varies with different vital capacities. But the watery condition of the blood itself, if increased either pathologically or by an increased addition of water, influences the water-excretion from the lungs, and may cause a considerable increase of it; so that taking Valentin's ratio of the blood-weight to the body-weight, viz.

[1] Valentin and Brunner, *Arch. f. d. phys. Heilk.*, vol. ii. p. 373.

1 : 13, there are sufficient factors present to make the amounts of water given off by the lungs vary extremely not only in different persons but in the same individual, and thus all averages are of doubtful value.

Valentin gives us a series of results on the question. He himself exhaled 384·48 grammes in twenty-four hours; eight young men each exhaled on an average 540 grammes (the thinnest individual 349·9 grammes, the stoutest 773·2 grammes). Calculating for each hour, Valentin himself exhaled 16 grammes, the thinnest man 14·57 grammes, the stoutest 32·22 grammes, and the average amount was 22·5 grammes. The daily watery excretion, with the shallowest breathing possible, is according to Valentin 288 grammes, with deep respirations 424·8 grammes. The amount exhaled in a given time diminished with increased activity of the respiration: with five respirations to the minute it was 0·287 gramme; with forty, only 0·205 gramme.

III. THE EXCRETION OF WATER BY THE SKIN AND LUNGS TOGETHER.

The results of Pettenkofer's and Voit's investigations lie before us on the excretion of water from the skin and lungs together under different conditions, viz. change in the quantity and quality of food, work, and rest. A period of twenty-four hours is taken in each case. Bearing in mind the results of Weyrich and Seguin, we shall in these calculations put down to the lungs about a third of the total amount of water excreted, and the remaining two-thirds to the skin. The figures obtained by Pettenkofer and Voit[1] vary between 814 and 2,042 grammes in twenty-four hours. The greatest amount occurs in the eighth experiment, in which the subject of examination worked hard for twelve hours on a moderate diet; while the lowest figures occur in the third observation, obtained during fasting and rest.

The following important figures for our therapeutic aim are taken from the investigations carried on by Pettenkofer and Voit on the amount of water given off from the skin and lungs together:—

[1] Pettenkofer and Voit, 'Untersuchungen über den Stoffverbrauch des normalen Menschen,' *Zeitschrift f. Biolog.*, vol. ii. part iv. p. 459. Munich, 1866.

Experiment	Water-excretion in grammes				
	Day	Night	Total	Per hour	
				Day	Night
I. Fasting. Rest . .	443·6	385·3	828·9	36·9	32·1
III. " "	462·6	351·5	814·1	38·5	27·6
IV. " Work . .	1425·3	353·2	1778·5	118·7	29·4
V. Moderate diet. Rest .	347·8	480·2	828·0	28·8	40·0
VI. " " .	534·9	474·4	1009·3	44·5	39·5
VII. " " .	449·9	507·5	957·4	37·4	42·2
VIII. " Work .	1102·9	939·6	2042·5	91·9	78·3
IX. " " .	1030·6	381·2	1411·8	85·8	31·7
X. Albuminous diet. Rest .	699·5	410·9	1100·4	58·2	34·2
XI. " " " .	639·9	567·6	1207·5	53·3	47·3
XII. Non-nitrog. " " .	564·5	360·9	925·4	47·0	30·0
XIV. Same diet morn. and even.	535·6	535·5	1071·1	44·6	44·6
XV. Moderate diet. Rest .	469·4	433·2	902·6	39·1	36·1

For our object, viz. the obtaining an increased excretion of water from the lungs, we must bear in mind many of the facts above stated. The air in the lungs is saturated with aqueous vapour, and the quantity of water removed from the lungs as aqueous vapour is in direct proportion to the quantity of air expired. This latter, however, is not dependent on the *frequency* of the respirations, but upon their *depth*, which becomes less with greater frequency. Finally, water is given off by the lungs, and evaporated from the surface of the respiratory tract according to the capacity of the external air for aqueous vapour, and this again depends on its warmth and dryness.

We shall therefore obtain an increased excretion of water from the lungs by making the separate inspirations as deep and as rapid as is possible with complete acts of breathing. It is less easy to make such breathing arbitrarily than when it is conducted apart from the will, automatically, and such breathing is most perfect on ascending elevations and in mountain climbing. It is simply impossible by any mere effort of the will to obtain such deep and frequent respirations as go on here for hours together in regular rhythm. Besides, the warmth and dryness of the air being factors of its capacity for moisture, we increase the evaporation from the lungs by breathing into an atmosphere which takes up moisture readily; and this is eminently the case with mountain air, not only on the summits of high mountains, but on hills fairly high. Here

the increased respiration, and the increased capacity of the air for moisture, combine to increase the water-excretion from the lungs to an extraordinary degree. Moreover, in mountain climbing the necessary muscular exertion causes strong excitation of the nerves governing the sweat-glands, independently of their excitation by external warmth, viz. the sun's heat.

Of sweat-inducing baths, the dry air of the Turkish bath (which in the tepidarium is heated to about 100° F., and in the sudatorium to about 117° F. and higher) influences the evaporation from the lungs more than the air of the vapour-bath, the temperature of which is about 105° F., and though higher than the temperature of the air in the lungs, is too saturated with aqueous vapour to take up any more. The sweat meanwhile is less influenced by this saturation, as it collects in drops and runs off the body as fast as it is formed. In the Turkish bath the rapid evaporation produces a continuous cooling effect, and renders the heat more endurable; accordingly a higher temperature and a longer sojourn in it are permissible than in the vapour bath. It is therefore necessary, in using vapour-baths, independently of the action of the heated and saturated air (which is above the normal temperature of the blood), to leave the apartment (usually after ten or fifteen minutes' stay), and to cleanse and dry the skin from sweat by cold douches, immersion in water, and rubbing down, and then *by a return to the vapour-bath to excite the sweat-nerves to renewed action by the sudden change of temperature.*

Where a rapid and decided removal of water from the body is required, it must be obtained (the supply of water to the system being lessened correspondingly) either by increased movement (if possible in the sun, as in hill-climbing) or by the Turkish bath; for here not only is the secretion of sweat extraordinarily increased, but a large amount of water is given off by the respiratory organs. The latter is derived not only from the vessels of the lungs, but from the surface of the respiratory mucous membrane; and this fact is of special importance in cases where the stasis has caused passive hyperæmia, swelling, and serous infiltration of the pulmonary tissues.

IV. EXPERIMENTS ON INCREASING THE CUTANEOUS AND PULMONARY WATER-EXCRETIONS.

In order to examine how much water can be excreted by the body under the influence of the physical methods at our disposal, a series of experiments were instituted, the results of which afford criteria for the application of these methods—on the one hand as to the number and sequence of the different ascents and mountain expeditions, on the other for the use of the sweating baths, both Turkish and vapour.

A. INCREASED WATER-EXCRETION BY EXERCISE.

It would have been very interesting to have indicated in the following pages the first therapeutic experiments which Dr. N. undertook, viz. his expeditions when at Tegernsee, and some of his later mountain rambles. But in the then desperate condition of the patient and the uncertainty of success, unfortunately no scientific observations were made. In the summer of 1882 Dr. N. attempted these observations in the mountains of Schliersee, where the weather was not the most favourable, and the high temperature of the summer of 1875 was not reached.

The experiments were conducted in the following manner. Every morning after the usual regular action of the bowels a simple breakfast was taken (about 150 c.cm. of coffee and 80 grammes of bread), the bladder was perfectly emptied, and the body-weight was taken without the clothing. The patient then set out on his expedition, and either refrained entirely from food and drink, or took steps to know the exact weight of whatever he took. On returning, the bladder was emptied afresh, and the body weighed as before (any urine passed during the journey was also weighed).

In order to ascertain the amount of water excreted by the skin and lungs during rest, a preliminary investigation was made, the patient avoiding all exertion. The figures so obtained were afterwards used for the periods of rest intervening between the later trying mountain-ascents, and thus a more accurate determination was made of the influences of severe muscular

exertion upon the watery excretions. For the sake of comparison, the loss of water from the body after a simple ordinary walk was also ascertained (Experiment II.), and with the result of this the physician has to deal at least for most of the year.

Experiment I.

Rest.—Sept. 5, 1882. Time, 3 hrs. 45 min. (from 8.30 A.M. to 12.15 A.M.) Except for a gentle walk in the garden, the patient sat quietly reading. Mean temperature, 83·6° F. Sky rather cloudy.

Food taken = 0		Urine = 106 grammes	
Body weight at 8.30 A.M. .	= 53·6 kilos.;	at 12.15 = 53·3 kilos.	
Total loss of weight in $3\frac{3}{4}$ hrs.	= 0·300 ,,	= 80 grammes per hour.	
Weight of urine . . .	= 0·106 ,,		
Loss by skin and lungs .	= 0·194 ,,[1]	= 43·7 ,, ,,	

Experiment II.

A Walk on Level Ground.—Sept. 11, 1882. Time, 3 hrs., from 9 to 12 A.M. Average temperature, 55·3° F.

Weight at 9 A.M. .	= 53·2 kilos.;	at 12 A.M. = 52·85
Total loss in three hours	= 0·350 ,,	= 116·6 grammes per hour
Weight of urine. .	= 0·148 ,,	
Loss by skin and lungs	= 0·202 ,,	= 67·3 ,, ,,

Experiment III.

Ascent of a Moderate Elevation.—Aug. 29, 1882. Walk up the Spitzing pass to Wurzelhütte; return over the Jägersteig by the Breeherspitze. Mean temperature in the sun = 83·6° F. (in the shade, 77° F.) Whole time = 3 hrs. 45 min., from 10.10 A.M. to 1.55 P.M.; of this 30 minutes was taken up in resting.

Food taken:—One piece of dry bread	= 70 grms.	containing	25·2 grms. water.
Enzian-liqueur .	= 34 ,,	,,	11·5 ,, ,,
Total . . .	= 104 ,,	,,	36·7 ,, ,,

Body weight before starting	= 53·550 kilos.	
Weight of food taken .	= 0·104 ,,	
Total	= 53·654 ,,	
Weight of body on return	= 52·550 ,,	
Total loss in $3\frac{3}{4}$ hours .	= 1·104 ,,	= per hr. 294·4 grammes.
Weight of urine passed .	= 0·150 ,,	
Loss by skin and lungs .	= 0·954 ,,	= ,, 255·2 ,,

[1] The figures 0·164 occur in the original.

If we reckon the loss of weight during the 30 minutes' rest at 40 grammes (vide Experiment I.), the total loss during $3\frac{1}{4}$ hours' walking=1·064 kilo.=per hour 327·4 grammes, and the loss by the skin and lungs=0·932 kilo.=per hour 286·8 grammes.

Experiment IV.

Exercise similar to the last.—Sept. 9, 1882. Route—over the Spitzing pass to Wurzelhütte, return by the old Spitzing way, ascent to Spitzingsee, and home by Umwegen on the Jägerkamp.

Start at 8.15 A.M.; Umwegen reached at 10.15. The last fifteen minutes were occupied in taking the body-temperature. Sharp ascent. Temperature taken under the tongue=38·25° C. (100·8° F.) Wurzelhütte reached at 10.30. Return commenced at 11. Home at 1.30.

External temp. at	8.45	= 80·2° F. in the sun; at	11	= 72·5° F.	cloudy sky.
,, ,,	9	= 89·2° ,, ,,	12	= 68·0°	,, ,,
,, ,,	10	= 90·5° ,, ,,	1.30	= 64·4°	,, ,,

Average temperature = 77·5° F.
Whole time expended = $4\frac{3}{4}$ hours
Time of resting . = $\frac{1}{2}$ hour

Period of exertion = $4\frac{1}{4}$ hours

Food taken:—One piece of dry bread	= 70 grms.	containing water	= 25·2 grms.
Enzian liqueur .	= 34 ,,	,, ,,	= 11·5 ,,
Total . . .	= 104 ,,	,, ,,	= 36·7 ,,

Weight of body before starting .	= 54·250 kilos.	
Weight of food	= 0·104 ,,	
Total	= 54·354 ,,	
Weight on return	= 53·100 ,,	
Total loss in $4\frac{3}{4}$ hours . . .	= 1·254 ,,	= per hour, 264 grammes
Weight of urine	= 0·191 ,,	
Loss by skin and lungs . .	= 1·063 ,,	= ,, 223·7 ,,

Or, deducting 40 grammes for the 30 minutes' rest, as before,

The total loss during $4\frac{1}{4}$ hours' exertion = 1·214 kilos. = per hour, 285·6 grms.
And the loss by skin and lungs = 1·041 ,, = ,, 244·9 ,,

Mountain Ascents.

Experiment V.

Ascent of the Jägerkamp.—Sept. 2, 1882. Start at 8. Jägerbauernalm reached at 10.30. Rest there, 30 min. Summit gained, 11.45. Return commenced at 12.45 P.M.; finished, 3.15 P.M. Whole time of expedition, 7 hrs. 15 min.; of active exertion, 5 hrs. 45 min.; of rest, 1 hr. 30 min.

Temperature in the sun at	8 A.M.	= 69° F.	
,, ,,	9	= 79·3°	
,, ,,	10	= 87·8°	
,, ,,	11.45	= 99·5°	(in the shade = 82·4° F.)
,, ,,	1 P.M.	= 101·3°	(,, ,, = 83·8°)
,, ,,	2	= 100·4°	(,, ,, = 83·8°)
,, ,,	3.15	= 97·3°	(,, ,, = 74·8°)
Mean temperature in the sun . .		= 89·5°	

Food taken :—Sausage . .	= 30 grms.,	containing water =	6·2 grms.
Bread . .	= 52 ,,	,, ,, =	20·9 ,,
Hungarian wine	= 96 ,,	,, ,, =	81·3 ,,
Water . .	= 170 ,,	,, ,, =	170·0 ,,
Total . . .	= 348 ,,	,, ,, =	278·4 ,,

Urine voided = 222·5 grammes

Body weight before starting .	= 53·850 kilos.	
Weight of food	= 0·348 ,,	
Total	= 54·198 ,,	
Body weight on return . .	= 52·150 ,,	
Total loss of weight in $7\frac{1}{4}$ hours	= 1·948 ,,	in one hour = 268·7 grammes
Weight of urine . . .	= 0·222 ,,	
Loss by skin and lungs . .	= 1·726 ,,	,, ,, = 238·0 ,,

Or, deducting 120 grammes for the $1\frac{1}{2}$ hour's rest (*vide* Exp. I.):—

Total loss during $5\frac{3}{4}$ hours' exertion	= 1·828 kilo.	= per hour, 317·9 grammes
Loss by skin and lungs . . .	= 1·660 ,,	= ,, 288·7 ,,

Experiment VI.

Ascent of the Rothwand.—Sept. 11, 1882. Start at 8.30 A.M. Wurzelhütte reached, 10 A.M., and left at 10.30. The lower Wallenburgeralm reached, 11.50. Stay there on account of rain till 12.15 P.M. Rothwand (summit) gained, 1.45 P.M. Return journey begun, 2.45 P.M. Grosstiefenthaleralm, 3.20. Start thence, 3.40. Geitau, 5.15. Home thence by carriage, 6 P.M. Time of expedition = 9 hrs. 30 min., of walking = 6 hrs. 30 min., of resting and driving = 3 hrs.

Temp. at	8.30 A.M. = 61·3° F.	cloudy sky; at	1 P.M.	= 70·3° F.	clear sky
,,	9 ,, = 77·9°	sunshine	2 ,,	= 77·0°	,,
,,	10.30 ,, = 90·5°	,,	3 ,,	= 72·5°	rather cloudy
,,	11 ,, = 72·5°	cloudy	4 ,,	= 79·3°	sunshine
,,	12 ,, = 68·0°	rain	5 and 6 ,,	= 65·8°	cloudy

Mean temperature = 72·8° F.

Food taken :—Sausage . .	= 51 grms.,	containing water =	10·5 grms.
Bread . .	= 87 ,,	,, ,, =	33·5 ,,
Wine . . .	= 145 ,,	,, ,, =	122·8 ,,
Enzian liqueur .	= 17 ,,	,, ,, =	5·7 ,,
Water . .	= 306 ,,	,, ,, =	306·0 ,,
Total . . .	= 606 ,,	,, ,, =	478·5 ,,

Urine voided = 363·5 grammes

Weight of body before starting	= 53·600 kilos.	
Food taken	= 0·606 ,,	
Total	= 54·206 ,,	
Weight of body on return. .	= 52·150 ,,	
Total loss in $9\frac{1}{2}$ hours . .	= 2·056 ,,	= per hour, 216·4 grammes
Loss by skin and lungs . .	= 1·693 ,,	= ,, 178·2 ,,

Or, deducting 240 grammes for the 3 hours' rest,

Total loss during $6\frac{1}{2}$ hours' exertion	= 1·816 kilo.	= per hour, 279·4 grammes
Loss by skin and lungs . . .	= 1·562 ,,	,, 240·3 ,,

Experiment VII.

Expedition to Jägerbauernalm.—Sept. 15, 1882. Start from Fischhausen, 9 A.M. Alm reached, 11.30. Complete rest there till 1.15 P.M. Home reached, 3 P.M. Time of expedition, 6 hrs.; of exertion, $4\frac{1}{4}$ hrs.; of rest, $1\frac{3}{4}$ hr. Temperature at 9 A.M. = 68° F., at 10 and 12 A.M. = 77° F., at 3 P.M. = 66·2° F. Mean temperature = 71·7° F. (of 7 observ.)

Food taken:—Sausage . .	= 40 grms.,	containing water =	8·3 grms.
Bread . .	= 52 ,,	,, ,, =	20·9 ,,
Butter . .	= 6 ,,	,, ,, =	0·8 ,,
Cheese . .	= 10 ,,	,, ,, =	3·5 ,,
Wine . . .	= 145 ,,	,, ,, =	122·8 ,,
Water . .	= 102 ,,	,, ,, =	102·0 ,,
Total . . .	= 355 ,,	,, ,, =	258·3 ,,

Urine voided = 233 grammes

Body weight before starting .	= 53·320 kilos.	
Increase due to food . . .	= 0·355 ,,	
Total.	= 53·675 ,,	
Weight after the expedition .	= 52·200 ,,	
Loss of weight in 6 hours . .	= 1·475 ,,	= per hour, 245·8 grammes
Loss by skin and lungs . .	= 1·242 ,,	= ,, 207·0 ,,

Or, allowing for the rest of $1\frac{3}{4}$ hr. (80 grms. per hour) = 140 grms.

Total loss of weight during $4\frac{1}{4}$ hours' work	= 1·335 kilo.	= per hour, 314·1 grms.
Loss by skin and lungs	= 1·166 ,,	= ,, 274·2 ,,

In the above calculation no regard was paid to the other products of tissue change in the respiration, the nitrogen and carbonic acid, their amounts being so small compared with the great loss of water, that they may be safely disregarded.

A direct estimation of the carbonic acid was out of the question, and as to the nitrogen in the urine, that could be better determined after the body had resumed its nitrogenous equilibrium, rest and work making so small a difference in its amount.

On the other hand, we may indirectly determine the carbonic acid and the nitrogen with sufficient accuracy from Pettenkofer's and Voit's investigations on the tissue changes in a healthy subject. Professor von Voit has had the kindness to forward us the following tables, for the calculation of the insensible respiratory products here interesting us.

(*a*) Obs. I. Within a period of 12 hours, during which the subject of experiment refrained from exertion, and took no food, there were destroyed

205 grms. of body-substance, representing	49·4	grammes	of dry flesh
" " " " "	123·0	"	of fat
Total	=172·4	"	solid tissue
In the urine were excreted	= 29·9	"	"
The remainder, excreted by the respiration, therefore	=142·5	"	for 12 hours
	= 11·87	"	for 1 hour

Deducting this amount (11·87 grammes per hour) of insensible respiratory products in our first experiment (rest), we obtain a loss of water by the skin and lungs for $3\frac{3}{4}$ hours=119·4 grammes.

(*b*) Obs. II. After 12 hours' work on a moderate diet, Voit found in the urine 9·41 grammes of nitrogen, representing 277 grammes of flesh or 66·8 grammes of dry flesh, together with 34·7 grammes of carbon. Of the latter, 7 grammes were found in the urine. There remain, therefore, 27·7 grammes of carbon in the respiration due to decomposition of body-substance.

But in the whole respiration 241·2 grammes of carbon were found, and therefore the amount due to decomposition of fat or carbohydrates (=241·2 – 27·7)=213·5 grammes.

If this be regarded as derived from fat, it represents 279 grammes of the latter; but if from oxidation of carbohydrates, it represents 500 grammes of these. Taking the half of these in our calculations, i.e. assuming that the subject of experiment decomposed as much fat as carbohydrates, we obtain

Fat	=139	grammes
Carbohydrates .	=250	"
Total	=389	"

the products of combustion of which were excreted by the lungs within 12 hours, or 32·4 grammes per hour. On deducting this amount per hour from the whole loss from the skin and lungs in Experiments III. to VII., we obtain the following results:

	Total loss from the skin and lungs	Loss of water alone from the skin and lungs
Exp. III., 3¼ hours' exertion	932·2 grammes	826·8 grammes
„ IV., 4¼ „ „	1041·0 „	903·1 „
„ V., 5¾ „ „	1660·0 „	1473·7 „
„ VI., 6½ „ „	1562·0 „	1351·3 „
„ VII., 4¼ „ „	1166·0 „	1027·7 „

The work done in the second experiment was not equal to that of the succeeding ones, nor to that done in Voit's eighth experiment, so that the excreted CO_2 due to tissue-change stands below 32·4 grammes per hour. Neither can the value obtained during rest be employed here, inasmuch as even slight muscular activity always caused a much greater destruction of non-nitrogenous substances than was the case with perfect rest. Using Voit's values, we obtain :

In the first case (work) = 102·3 grammes
In the second (rest) . = 166·3 „
Or a mean of . . = 134·3 „

representing the water loss from the skin and lungs during three hours' walking.

TABULAR VIEW.

Loss of Water from the Human Body during the Severe Exertion of Mountain-Ascents.

No.	Valley-level	Time of expedition and of ascent in hours	Mean temp. in degrees C.	Body-weight in kilos.	Total loss of body weight in kilos.	Loss of weight by urine in grammes	Loss by skin and lungs in kilos.	Per hour: Total loss in grammes	Per hour: Water-loss by skin and lungs
I.	—	{3¾ / —}	18·2	53·600	0·300	136·0	0·164	{80 / rest}	{31·8 / rest}
II.	—	3	13·2	53·200	0·350	148·0	0·202	116·6	34·1
III.	362	{3¾ / 3¼}	28·7	53·550	1·104	150·0	0·954	327·4	254·4
IV.	362	{4¾ / 4¼}	25·3	54·250	1·254	191·0	1·063	285·6	212·5
V.	957	{7¼ / 5¾}	32·2	53·850	1·948	222·5	1·726	317·9	256·3
VI.	1104	{9½ / 6½}	22·7	53·600	2·056	363·5	1·693	279·4	207·9
VII.	768	{6 / 4¼}	22·1	53·320	1·475	233·0	1·242	314·1	241·8

The above figures show that the amount of work done is the chief factor in the water-excretion of the body. This is

most clearly shown by calculating the loss of body-weight in each case after subtracting the time spent in rest.

In Experiment II. (a walk on level ground) the total loss per hour is only 116·6 grammes; in Experiment III., where a height of 362 metres was ascended and descended in $3\frac{1}{4}$ hours, the loss of weight rises to 327·4 grammes per hour, whereas in the same experiment if the whole time be taken, viz. $4\frac{1}{4}$ hours, the loss of weight per hour is only 285·6 grammes. When a far higher and steeper ascent was made in the same time (Experiment VII., 768 metres), the loss of weight increased to 314·1 grammes per hour, and would have been still more had not the temperature been 5·7° F. lower than in the above experiment.

In Experiment V., where an elevation of 957 metres was ascended, the period of exertion being $5\frac{1}{4}$ hours and the temperature 90° F., the total loss was 317·9 grammes per hour; and finally, in Experiment VI., where 1,104 metres were ascended, the temperature being 73° F., and the period of exertion $6\frac{1}{2}$ hours, the loss of weight per hour sank to 279·4 grammes. Thus, the greatest loss of weight per hour occurred in Experiment III. *when the work was done in the least time*; on the other hand, the longer the time taken, the smaller was the loss per hour, so that in Experiment VI., where double the time was expended ($6\frac{1}{2}$ hours), the loss of weight per hour is less than in Experiment III., although 742 metres higher were ascended.

Mere difference of temperature is not of much influence on the loss of weight, as is seen at once on comparing Experiments VI. and VII., where the temperatures were 72·8° F. and 71·7° F., and where, although the former temperature was higher by 1·1° F., the total loss per hour is 34·7 grammes less, and the loss by the skin and lungs 33·9 grammes less. On the other hand, the period of work was $6\frac{1}{2}$ hours in Experiment VI., and only $4\frac{1}{4}$ hours in Experiment VII.

It results further from these experiments that the sweat-production is limited as to time, and a steady decline of it accompanies a prolonged excitation of the sweat-nerves, though the quantity will still much exceed that produced during rest. During the experiment itself the blood received no sufficient compensation for the water it had lost from the skin and lungs, because the fluid supply was extremely restricted, and the small

quantity taken was spread over a long interval of time and not given all at once, so that it may be considered as wholly or nearly excreted in the urine.

Glancing at Pettenkofer's and Voit's figures for the watery excretion from the skin and lungs during rest and work, we find the highest in Exp. VIII. (for 12 hours' work = 1102 grammes, or 91·9 grammes per hour), in contrast with our Experiment V., viz. $5\frac{3}{4}$ hours' active exertion and 256·3 grammes per hour. Thus their maximum of 1102·9 grammes for twelve hours is exceeded by our 1473·7 grammes for $5\frac{3}{4}$ hours by 370·8 grammes. On the other hand, the values in our Experiments I. and II. (rest and gentle exercise), in which 31·8 and 34·1 grammes per hour of water were excreted by the skin and lungs, quite agree with Pettenkofer's and Voit's, and the slight difference is accounted for by the greater imbibition of water in Voit's subject during the twelve hours observed.

The utter impracticability of calculating for twelve hours, or the whole twenty-four hours, from the high figures obtained in shorter periods of time is most strikingly shown in the above experiments, where the water-excretion declines as the period of exertion becomes longer.

According to the patient's recollection, the sweating was far more copious in 1875, and his clothes were saturated to a much greater degree then on his expeditions than in 1882. This was due to the extreme hydræmia at that time, the unwonted muscular exertion, and the sudden dyspnœic excitations, which in a moment caused fresh and persistent sweating, whereas in the above experiments he had to walk a good while before beginning to perspire ; and even then he perspired less than his companions.

Therefore the above figures must not be regarded as unusual amounts seldom reached, but on the contrary as values which may be relied upon, and which may be increased if desired.

B. INCREASED WATER-EXCRETION UNDER THE INFLUENCE OF HEAT.

After the above investigations, the determination of the water that may be lost from the body by the action of heat, by warm dry air, and warm moist air respectively, most interests us.

It is indispensably necessary to possess other methods of increasing the watery excretions, and thereby obtaining a corresponding unloading of the circulation by a large watery loss from the skin and lungs, than those which depend on exertion, since the latter are too much bound up with the weather and the time of year, and hence cannot always be carried out when necessary. The methods of dehydration to be described are evidently not equivalent to exercise, inasmuch as they exert no influence on the heart, as will be presently shown, and after the intended more or less thorough removal of water, the previous compensations remain unaltered, and so does the weak, atrophied, and fatty heart-muscle.

The following experiments were carried out in the extremely well arranged baths of Herr Kolditz in Munich, and their object was to estimate the amount of water thrown off:

a, by hot dry air (Turkish bath),

b, by hot moist air (vapour-bath).

The subjects of experiment were visitors to the baths, healthy strong men of various ages, heights, and weights, who most kindly placed themselves at my disposal.

a. Under the Influence of Hot Dry Air.

Experiments in the Turkish Bath.

The arrangement of the above baths is such that the bather passes from a roomy hall, built and decorated in the Moorish style, with couches in separate compartments for packing after the bath, into the *tepidarium*, where he is exposed to warm dry air of the temperature of 112° F. or thereabouts. Next to this is the *sudatorium*, with a temperature of about 135° F., where the bather stays ten or twelve minutes, after having remained some while in the tepidarium. It is usual before entering the sudatorium to excite the action of the skin by gymnastic movements, kneading, friction with coarse towels, and massage, and after leaving it to gradually lower the cutaneous activity by warm and cold douches, and a plunge into cold water. But after the bather has been energetically rubbed down, the cutaneous activity is kept elevated for some time by enveloping in blankets, &c.

The determinations of the watery loss in the Turkish bath were made thus. The bather first emptied his bladder perfectly, and then stripped and entered the tepidarium, the time of his entrance being noted. Before entering the sudatorium he was well ‘massaged’ by the attendants, and in order to ascertain what influence massage had upon the perspiration, I caused each of the persons at my disposal to undergo massage in one experiment, and to go without it in another. As a rule, they stayed only a short time in the sudatorium, and then returned to the tepidarium, which they left at their pleasure, the time of leaving being again carefully noted. In order to avoid too rapid cooling, the bather was subjected to cold douching, took a plunge into cold water, and reappeared in the first saloon, where he was dried and rubbed down. This finished, and the bladder being emptied again (the urine being measured as before), he reweighed and then dressed himself. The difference of weight, allowance being made for any urine passed while in the bath, gives the loss of water from the skin and lungs under the action of hot dry air.

Loss of Water from the Body in the Turkish Bath.

I. A. K. Temp. of tepidarium, 124·7° F.; of sudatorium, 137·8° F.

Without massage, Oct. 18, 1882.		*With massage, Oct.* 19, 1882.	
Time of stay in bath	= 45 min.	Time in bath	= 35 min.
Weight before bath	= 62·820 kilos.	Weight before bath	= 63·050 kilos
„ after „	= 62·050 „	„ after „	= 62·000 „
Loss by skin and lungs	= 0·770 „	Loss by skin and lungs	= 1·050 „
Urine	= 0 „		

II. S. K. Temp. of tepidarium, 124·7° F.; of sudatorium, 137·8° F.

Without massage, Oct. 19, 1882.		*With massage, Oct.* 20, 1882.	
Time in bath	= 40 min.	Time in bath	= 38 min.
Weight before bath	= 47·900 kilos.	Weight before bath	= 48·330 kilos.
„ after „	= 47·320 „	„ after „	= 47·780 „
Total loss	= 0·580 „	Total loss	= 0·550 „
Urine	= 0·0265 „	Urine	= 0·0275 „
Loss by skin and lungs	= 0·5535 „	Loss by skin and lungs	= 0·5225 „

III. J. H. Temp. of tepidarium, 124·7° F.; of sudatorium, 137·8° F.

Without massage, Oct. 19, 1882.			*With massage, Oct.* 20, 1882.		
Time in bath	= 43 min.		Time in bath	= 42 min.	
Weight before bath	= 64·530	kilos.	Weight before bath	= 64·550	kilos.
,, after ,,	= 63·680	,,	,, after ,,	= 63·770	,,
Total loss	= 0·850	,,	Total loss	= 0·780	,,
Urine	= 0·0175	,,	Urine	= 0·036	,,
Loss by skin and lungs	= 0·8325	,,	Loss by skin and lungs	= 0·744	,,

IV. S. E. Temp. of tepidarium, 122° F.; of sudatorium, 135·5° F.

Without massage, Oct. 21.			*With massage, Oct.* 24.		
Time in bath	= 44 min.		Time in bath	= 46 min.	
Weight before bath	= 119·480	kilos.	Weight before bath	= 118·130	kilos.
,, after ,,	= 118·580	,,	,, after ,,	= 117·330	,,
Total loss	= 0·900	,,	Loss by skin and lungs	= 0·800	,,
Urine	= 0·050	,,	Urine	= 0	,,
Loss by skin and lungs	= 0·850	,,			

V. R. E. Temp. of tepidarium, 122° F.; of sudatorium, 135·5° F.

Without massage, Oct. 21.			*With massage, Oct.* 24.		
Time in bath	= 45 min.		Time in bath	= 55 min.	
Weight before bath	= 100·000	kilos.	Weight before bath	= 100·780	kilos.
,, after ,,	= 99·200	,,	,, after ,,	= 99·780	,,
Total loss	= 0·800	,,	Total loss	= 1·000	,,
Urine	= 0·0185	,,	Urine	= 0·021	,,
Loss by skin and lungs	= 0·7815	,,	Loss by skin and lungs	= 0·879	,,

VI. K. M. Temp. of tepidarium, 122° F.; of sudatorium, 135·5° F.

Without massage, Oct. 21.			*With massage, Oct.* 23.		
Time in bath	= 46 min.		Time in bath	= 41 min.	
Weight before bath	= 48·650	kilos.	Weight before bath	= 48·120	kilos.
,, after ,,	= 48·080	,,	,, after ,,	= 47·660	,,
Total loss	= 0·570	,,	Total loss	= 0·560	,,
Urine	= 0·0595	,,	Urine	= 0·028	,,
Loss by skin and lungs	= 0·5105	,,	Loss by skin and lungs	= 0·532	,,

VII. M. K. Temp. of tepidarium, 124·7° F.; of sudatorium, 137·8° F.

Without massage, Oct. 20.

Time in bath . . .	= 40 min.	
Weight before bath .	= 68·550	kilos.
,, after ,, .	= 68·110	,,
Total loss . . .	= 0·440	,,
Urine	= 0·0355	,,
Loss by skin and lungs .	= 0·4045	,,

VIII. R. O. Temp. of tepidarium, 124·7° F.; of sudatorium, 137·8° F.

With massage, Oct. 20, 1882.

Time in bath . . .	= 50 min.		
Weight before bath .	= 81·060	kilos.	
„ after „ .	= 80·020	„	
Total loss . . .	= 1·040	„	
Urine	= 0·0365	„	
Loss by skin and lungs .	= 1·0035	„	(= 35·8 ozs.)

TABULAR VIEW.

Loss of Water from the Body in the Turkish Bath.

No. *a* without massage *b* with „		Time in minutes	Temperature in degrees F. Tepidar.	Sudator.	Weight of body in kilos.	Total loss of weight in kilos.	Urine in grms.	Loss by skin and lungs in kilos.
I. A. K.	*a*	45	125	138	62·820	0·770	—	0·770
	b	35	„	„	63·050	1·050	—	1·050
II. S. K.	*a*	40	„	„	47·900	0·580	26·5	0·5535
	b	38	„	„	48·330	0·550	27·5	0·5225
III. J. H.	*a*	43	„	„	64·530	0·850	17·5	0·8325
	b	42	„	„	64·550	0·780	36·0	0·744
IV. S. E.	*a*	44	122	135·5	119·480	0·900	50·0	0·850
	b	46	„	„	118·130	0·800	—	0·800
V. R. E.	*a*	45	„	„	100·000	0·800	18·5	0·7815
	b	55	„	„	100·780	1·000	21·0	0·979
VI. K. H.	*a*	46	„	„	48·650	0·570	59·5	0·5105
	b	41	„	„	48·120	0·560	28·0	0·532
VII. M. K.		40	125	138	68·550	0·440	35·5	0·4045
VIII. R. O.		50	„	„	81·060	1·040	36·5	1·0035

Reviewing the results obtained by the above experiments we find:

1. That we may look upon the loss of weight under the action of hot dry air *as a purely watery loss.* The time of experiment was too short, and the bather too much at rest excepting for a few minutes, for any particular tissue change to have occurred sufficiently to have affected the weight. At the most, 10 or 15 grammes would be enough to represent it—a quantity utterly insignificant beside the high figures in the table.

2. In most of the experiments the amount of sweating

was proportionate to the length of time spent in the bath, except in Experiments I. and IV.

3. Neither the size nor the weight of the individual had any direct influence on the amount of water given off by the skin and lungs.

4. The passive gymnastic by massage, which was carried out in the first six experiments, only twice increased the sweat-production (Experiments I. and IV.) Massage cannot, therefore, be depended on practically for this object.

5. Finally, it can scarcely be doubted that in patients with circulatory disorders and hydræmia, even if they cannot remain so long in the bath as the above persons did, yet the figures above given will be reached, or even exceeded, in proportion to the duration of the bath, except in *severe œdema*, with great tension of the skin- and compression of the sweat-glands and the capillaries encircling them, causing *arterial anæmia* of the glands. (See 'Clinical Histories,' No. 9.)

b. By the Action of Hot Moist Air.

Experiments in the Vapour-Bath.

Like the Turkish bath, the vapour-bath consisted of an entrance saloon, a room for douches and baths, and the vapour-room proper, which is entered from the latter. The temperature of the vapour-bath was not so constant as that of the tepidarium, and varied between 100·8° F. and 122° F.

The experiments were conducted in the same way as in the Turkish bath, and on men of different ages, sizes, and weights. Inasmuch as the bather here, after having remained some time in the vapour-room, left it to be cooled down by cold douches and baths, and then re-entered it and remained some time before finishing the bath, the time of each separate stay in the vapour-room was carefully noted. The weight of the body and the amount of urine passed were determined as in the Turkish bath. The difference between the first and second weighings (the weight of any urine passed being deducted) gave the amount of water-loss from the skin and lungs, which the body underwent under the influence of warm moist air.

WATER-LOSS OF THE HUMAN BODY IN THE VAPOUR-BATH.

I. A. M., Oct. 24, 1882. First stay in vapour-room=32 min., second stay=16 min.; total=48 min. Highest temperature reached =116·6° F. Weight of urine, 47 grammes.

Weight before bath .	=81·000	kilos.
„ after „ .	=80·500	„
Total loss . . .	= 0·500	„
Weight of urine . .	= 0·047	„
Loss by skin and lungs .	= 0·453	„

II. A. M., Oct. 26. First stay=29 min., second=13 min.; total =42 min. Highest temperature reached=117·5° F. for a few minutes. It then sank to 113° F., and finally remained pretty constant at 106·8° F. Urine=5 grammes.

Weight before bath .	=81·030	kilos.
„ after „ .	=80·450	„
Total loss . . .	= 0·580	„
Urine	= 0·005	„
Loss by skin and lungs .	= 0·575	„

III. R. H., Oct. 28. First stay=17 min., second=25 min.; total =42 m. Temperature as in Experiment II. Urine=20 grammes.

Weight before bath .	=114·950	kilos.
„ after „ .	=114·450	„
Total loss . . .	= 0·500	„
Urine	= 0·020	„
Loss by skin and lungs .	= 0·480	„

IV. H. P. First stay=12 min., second=21 min.; total=33 min. Temperature as before. Urine=7 grammes.

Weight before bath .	=73·660	kilos.
„ after „ .	=72·910	„
Total loss . . .	= 0·750	„
Urine	= 0·007	„
Loss by skin and lungs .	= 0·743	„

V. A. M., Oct. 28. First stay in bath=20 min., second=20 min.; total=40 min. Temperature (constant)=113° F. Urine=10 grammes.

Weight before bath .	=80·380	kilos.
„ after „ .	=79·880	„
Total loss . . .	= 0·500	„
Urine	= 0·010	„
Loss by skin and lungs	= 0·490	„

VI. F. K., Oct. 28. First stay=20 min., second=18 min.; total=38 min. Temperature (constant)=113° F. Urine=120·5 grammes.

Weight before bath	= 61·980	kilos.
„ after „	= 61·530	„
Total loss	= 0·450	„
Urine	= 0·1205	„
Loss by skin and lungs	= 0·3295	„

VII. A. M., Oct. 30. First stay=12 min., second=7 min.; total=19 min. Temperature at the beginning of the bath=115·3° F., then rose slowly to 122° F.

Weight before bath	= 81·560	kilos.
„ after „	= 81·080	„
Total loss	= 0·480	„
Urine	= 0·011	„
Loss by skin and lungs	= 0·469	„

VIII. R. H., Oct. 30. First stay=9 min., second=6 min.; total=15 min.

Weight before bath	= 115·760	kilos.	
„ after „	= 115·538	„	
Total loss	= 0·222	„	(Urine = 0)

Tabular View of the Loss of Water in the Vapour-Bath.

No.	Time in minutes	Temperature in degrees F.	Weight of body in kilos.	Total loss of weight in kilos.	Weight of urine in grammes	Loss by skin and lungs in kilos.
I.	48	116·6	81·000	0·500	47·0	0·453
II.	42	{117·5, 106·8}	81·030	0·580	5·0	0·575
III.	42	„	114·950	0·500	20·0	0·480
IV.	33	„	73·660	0·750	7·0	0·743
V.	40	113	80·360	0·500	10·0	0·490
VI.	38	„	61·980	0·450	120·5	0·3925
VII.	19	{115·3, 122·0}	81·560	0·480	11·0	0·479
VIII.	15	„	115·760	0·222	0·0	0·222

Conclusions.

1. The loss of weight in the vapour-bath, as in the Turkish bath, is purely a watery loss, since for similar reasons we may neglect the loss of weight due to the products of tissue-change.

2. The loss of water is less than in the Turkish bath. This

may be caused, firstly by the lower temperature, and secondly because the saturated air of the vapour-bath cannot take up so much water from the lungs as the air of the Turkish bath.

3. The amount was for the most part exactly proportional to the length of stay in the bath. In Obs. II., the bather lost 500 grammes in weight after a stay of 42 minutes (480 grammes from the skin and lungs), while in Obs. VIII. the same person only lost 222 grammes after a stay of 15 minutes. But Obs. IV. forms an exception to this, as the greatest loss (743 grammes) occurred, in this case, after a stay of 33 minutes.

4. No special connection was found to exist between the extent of body-surface and the amount of sweat. In Obs. III. a person weighing 114·95 kilos. lost 480 grammes from the skin and lungs, while in Obs. IV., with a weight of 73·66 kilos. and a shorter stay in the bath, as much as 743 grammes was lost.

The dependence of the production of sweat upon the higher or lower excitability of the sweat-nerves of the individual is unmistakably apparent in both the Turkish and vapour-baths.

C. INCREASED WATER-EXCRETION AFTER PILOCARPINE INJECTIONS.

The fourth method of increasing the perspiration, and thereby reducing the fluids of the body, is based on the influence of pilocarpine upon the sweat-glands, when injected subcutaneously in the right quantity. We can by no means dispense with this method. If any one of the above physiological methods be thoroughly carried out, there will be no need for the use of the far more active pilocarpine injections. But in many cases none of the above methods are available; the weather or other reasons may prevent our having recourse to hill-climbing, and the Turkish and vapour-baths may not be at hand. Under such circumstances we possess a sufficient substitute in pilocarpine injections, as far as increased excretion of water is concerned.

According to Leyden's investigations,[1] there is no reason to

[1] E. Leyden, 'Ueber die Wirkungen des Pilocarp. mur.,' *Berl. klin. Wochenschr.*, vol. xiv. No. 28, p. 406.

imagine that pilocarpine has any weakening influence on the heart muscle. The symptoms of collapse occasionally seen after its use are not due to this but to nausea and vomiting.

More dangerous than this is the much rarer increased secretion of mucus by the respiratory tract, where there is marked lowering of the vital capacity (especially when *spastic neuroses—e.g.* hiccough—are present) or insufficient breathing, and especially suffocative attacks. Under such circumstances, a merely slight increase of watery excretion from the bronchi may entail a series of annoying and even alarming symptoms.

On the other hand, when the lungs are free, and the heart is not too weak, the injections are without exception well borne. In all cases, however, the patient should be watched for a time, either by the physician or by some trustworthy attendant.

The following experiments on the increased water-excretion from the skin and salivary glands, under the influence of pilocarpine injections, were carried out by the kindness of Professor Ziemssen in the General Hospital of Munich. They may be appended to the foregoing experiments, both from their general interest and because they contain the facts we require.

Water-loss of the Human Body after Pilocarpine Injections.

Experiment I.

Man, æt 53. Facial paralysis. The bladder being emptied, 0·02 grm. (0·3 gr.) of pilocarpine muriate was injected under the skin at 11.48 A.M. Pulse at once slower and irregular; later on regular, but quickened and tense.

After 3 min. = salivation.
,, 4 ,, = moisture on breast.
,, 5 ,, = ,, on face (both sides equally).
,, 8 ,, = upper limbs moist, lower limbs beginning to be so.

After $2\frac{1}{2}$ hours the surface was fairly dry again, and no urine could be passed.

Weight of body before injection	= 61·610 kilos.
,, after	= 61·015
Loss	= 0·595

Experiment II., Jan. 17.

Woman, æt 28. Chronic nephritis; hypertrophy of left ventricle; post-partum amaurosis. 0·02 grm. pilocarpine injected. Profuse sweating and salivation. Saliva not weighed.

Weight before injection	= 68·700	kilos.
„ after „	= 67·900	„
Loss	= 0·800	„

Experiment III.

Same patient. 0·02 grm. pilocarpine injected.

Weight before injection	= 68·440	kilos.
„ after „	= 67·480	„
Loss	= 0·960	„

Experiment IV.

Same patient. 0·015 grm. pilocarpine injected.

Weight before injection	= 68·260	kilos.
„ after „	= 67·300	„
Loss	= 0·960	„

Experiment V.

Man, æt 65. Cirrhosis of both apices of lungs. 0·015 grm. pilocarpine injected, after bladder and rectum were emptied.

Weight before injection	= 42·960	kilos.
„ after „	= 42·400	„
Loss	= 0·560	„

Experiment VI., No. I.

Ward No. 14, bed No. 6. 0·015 grm. pilocarpine injected. Saliva = 160 grms.

Weight before injection	= 32·320	kilos.
„ after „	= 31·940	„
Loss	= 0·380	„

Experiment VII., No. II.

Ward No. 14, bed No. 10. 0·02 grm. pilocarpine injected. Saliva = 356 grms.

Weight before injection	= 55·000	kilos.
„ after „	= 54·100	„
Loss	= 0·900	„

Experiment VIII.

Ward No. 17, bed No. 1. 0·02 grm. pilocarpine injected. Saliva=29 grms.

Weight before injection	=46·260 kilos.	
„ after „	=44·900 „	
Loss	= 1·360 „	

Experiment IX.

Ward No. 17, bed No. 12. 0·02 grm. pilocarpine injected. Saliva=350 grms.

Weight before injection	=70·000 kilos.	
„ after „	=68·600 „	
Loss	= 1·400 „	

Experiment X.

Ward No. 27, bed No. 12. 0·02 grm. pilocarpine injected. Saliva=84 grms.

Weight before injection	=58·780 kilos.	
„ after „	=58·000 „	
Loss	= 0·780 „	

TABULAR VIEW.

Loss of Water from the Human Body after Pilocarpine Injections.

No.	Pilocarpine in grms.	Weight of body in kilos.	Weight of mucus and saliva in grms.	Urine	Loss of weight of body in kilos.	Loss of weight deducting saliva and mucus, in kilos.
I.	0·02	61·610	—	—	0·595	—
II.	„	68·700	—	—	0·800	—
III.	„	68·440	—	—	0·960	—
IV.	0·015	68·260	—	—	0·960	—
V.	„	42·900	—	—	0·500	—
VI.	„	32·320	0·160	—	0·380	0·220
VII.	0·02	55·000	0·356	—	0·900	0·544
VIII.	„	46·260	0·029	—	1·360	1·331
IX.	„	70·000	0·350	—	1·400	1·050
X.	„	58·780	0·084	—	0·780	0·696

On considering the above figures, they are found to be large, although they cannot be regarded as expressing loss of water alone. The duration of the experiments was from two and a half to three hours, and therefore some oxidation of nitrogenous tissue and fat must have occurred, and part of the solids of the body must have disappeared in the urine, and in the saliva and

mucus. These last amounted in one experiment to as much as 350 grammes. But in a total loss of weight of 1,400 grammes, the decomposition of solids in the time given could take no share worth mentioning.

The amount of saliva is in no relation to the loss of weight. In Experiment VI. the quantity of saliva and mucus was 160 grammes and the total loss of weight 380 grammes, while in Experiment VIII. only 29 grammes of saliva were lost, with a loss of weight of 1,360 grammes. Again, in Experiment IX. there were 350 grammes of saliva, while the loss of weight was 1,400 grammes. Neither is the loss of weight proportionate to the weight of the body.

On the other hand, the quantity of pilocarpine injected is of great importance both as to sweating and salivation. That in certain cases great results are obtained by small doses is shown in Experiment IV., in which the same loss of weight (960 grammes) occurred after 0·015 gramme, as in Experiment III., where one-third more pilocarpine was injected.

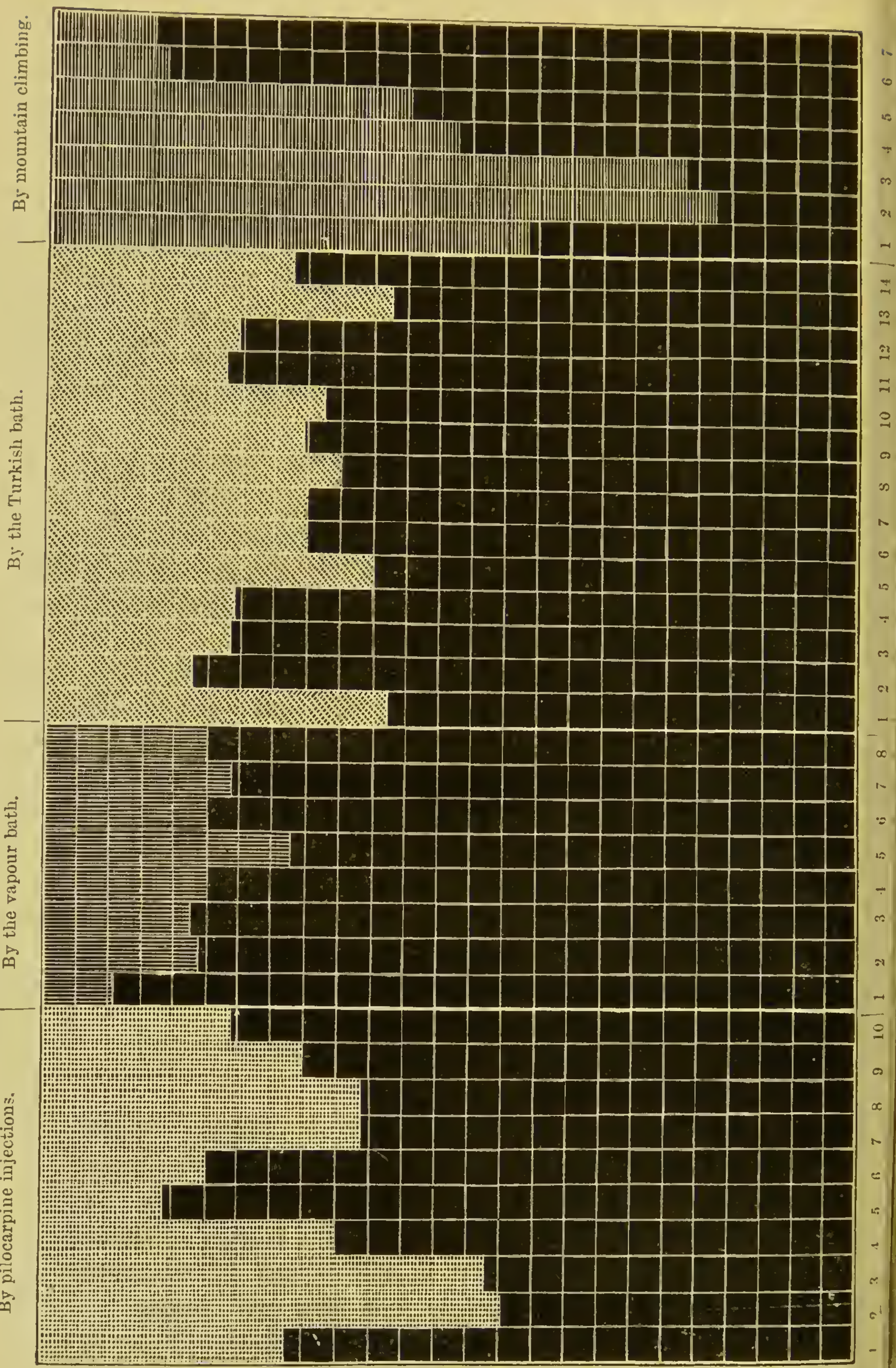
Finally, it may be mentioned that the susceptibility to pilocarpine varies not only amongst different persons, but in the same individual, equal quantities at different times causing different effects.

The degree of influence of pilocarpine upon the excretion of water, as well as the degree of untoward influence on the respiration by the accumulation of mucus (causing spasmodic nervous attacks, discomfort, vomiting, and even collapse), cannot in some cases be foreseen.

General Results of the preceding Different Experiments.

If we graphically represent the loss of weight obtained by each of the different methods of withdrawing water from the body, the highest figures are found to be those obtained in the experiments on strenuous bodily exertion (mountain-ascents). Even moderate work, an ascent of 362 metres above the valley-level, entailed a loss of weight not observed in any of the observations in the Turkish or the vapour-bath. Next to the latter come the results of pilocarpine injections, the constancy

Fig. 1.—Graphic Representation of the Loss of Weight obtained by the Different Methods.



Each square = 100 grammes.

of which we cannot always depend upon, as I have often experienced.

On comparing the loss of weight with the weight of the blood in each case, we find that in a person weighing 70 kilos., the weight of whose blood may be assumed to be 5 to 5·4 kilos. (*i.e.*, according to Bischoff,[1] 0·071 to 0·078 time the body-weight), we obtain a reduction of the fluids of the body amounting to from $\frac{1}{10}$ to $\frac{1}{5}$ of the blood-mass when there is a loss of water of 500 to 1,000 grammes, or, assuming the higher value of Bischoff, of 0·09 to 0·18 time the blood-mass.

In our patient, whose weight was 53·4 kilos., the blood weighed 3·5 to 4·1 kilos. (according to Bischoff's ratio), and the watery loss which he sustained in Experiments III. and V.—viz. 827 and 1,474 grammes—indicated a reduction of $\frac{1}{5}$ to $\frac{2}{5}$ of the blood.

Taking Weber's and Lehmann's [2] estimate of the blood-ratio (viz. 0·125 time the body-weight), there would have been 6·7 kilos. of blood, and the diminution was 0·123 to 0·22 time this.

It will now be asked how the body is affected by very considerable loss of water, and how this loss is to be induced in cases of disease.

Under normal conditions the fluids of the tissues and vessels will adapt themselves to the new hydrostatic relations after such loss. The vessels, unless the arterial pressure be lowered, as after severe exertion, will lessen their diameters and transmit a smaller quantity of blood, and these alterations will be evident in the wall of the artery. In a secondary degree the loss will be also met by the influx of water from the tissues and the supply by drinking if this occur. Thus the previous hydrostatic relation between the fluids in the vessels and those in the tissues is soon re-established. If the entry of water from without be restricted, and the loss of water be repeated, there arrives a period when the water drawn from the blood cannot be replaced. The blood then becomes thicker, and its persistent diminution would be followed ultimately by death from deprivation of fluid—death from thirst.

If owing to disease large quantities of fluid are collected in the subcutaneous connective tissue or in the cavities of

[1] Bischoff, *Zeitschr. f. wissensch. Zoologie*, vii. p. 331, 1855; ix. p. 65, 1857.
[2] Lehmann, *Physiol. Chemie*, 2nd edit. ii. p. 234. Leipzig, 1853.

the body, they will be gradually taken up into the vessels on continued withdrawal of water from the body, and will finally be made to disappear altogether.

We may see this in patients with general dropsy, when attacked by cholera. If in such patients as survive, the previous liver- or kidney-disease is found to be no longer present, it is because the balance between the arterial and venous circulations is again fairly established with the disappearance of watery transudations and retrogression of the venous stasis.

If now in the cases that interest us we desire to keep the fluids of the body reduced, whatever method of withdrawal of water we may have chosen, it will be necessary to restrict as far as possible the imbibition of water, and to lower it to the degree which the patient can bear without suffering much from thirst. Loss of water from the body by the skin and lungs cannot now be made up from without. On the other hand, the hydræmic blood of the patient will bear this better than blood of normal composition; the fluids exuded into the tissues will slowly give up their water to the blood, and thus the loss will be gradually covered. If the withdrawal of water be repeated, if the amount thrown off constantly exceed the amount supplied, sooner or later the blood will part with all or most of its excess of water and the loss will be made up only by increased absorption of fluids which have transuded into the tissues. In this relation of the water-excretion to the water-supply and to the fluids of the body generally, lies the possibility of *compensating the deranged balance* in the circulatory apparatus, and the preservation of the new condition depends on the *regulation* of the amount of fluid supplied and excreted.

How far in any particular case a more or less perfect elimination of the circulatory disorder and a return to the normal may be attained will depend on the relative integrity of the organs chiefly concerned—the heart, lungs, and kidneys; and also on our being able to re-establish any previous compensations, which from some cause or other have failed. These are points, however, which do not belong to an experimental investigation into the possibility of reducing the fluids of the body, and we must defer to a later chapter both their explanation and the practical experiments connected with them.

B. *INVESTIGATIONS ON FAT-DESTRUCTION IN THE BODY. FAT-REDUCTION.*

ON METHODS OF FAT-REDUCTION IN GENERAL.

If we are obliged to introduce the treatment of obesity on its own account, it is mainly because this condition is a far-reaching cause of circulatory derangement, not only in the cases which chiefly interest us in this work, but in other diseases, to which our attention will be directed presently, and most of all when there is an abnormal accumulation of fat upon the heart, impeding its functions.

In treating obesity from our standpoint, we must distinguish between (*a*) cases in which the excessive development of fat has already induced cardiac insufficiency and circulatory disorder, and (*b*) cases in which these results have not as yet occurred.

The treatment of cases of the first kind will be directed for the most part on the dietetic principles proper to cases of the latter kind, but the difference between the two categories is too great to allow us to obtain a sufficient circulatory balance by the carrying out of these principles alone, even if fresh evils be not introduced, in processes already very unfavourable.

But if the circulatory apparatus is still intact, if the obesity is essentially plethoric, it will suffice if we effect—

1. An alteration in the quantity and quality of the food, according to the nutritive laws established by Pettenkofer and Voit;

2. An alteration in the life led by the patient, viz. the passing from a life of excessive rest and comfort to one of activity and hard work, in order both to induce a decided reduction of the accumulated fat by increased oxidation, and to prevent its renewal by inappropriate food.

The physiological principle on which it has been attempted to effect combustion of the fat stored up in the body, and prevention of fresh formation of fat, consists in the more or less exclusive use of highly nitrogenous food, and the oxidation of the fat of the body induced thereby.

As far back as 1850 Chambers [1] arranged a diet for obesity, in which fat and milk were omitted altogether, starch-stuffs in the form of potatoes and bread were allowed only in the smallest quantities, and the food was almost entirely nitrogenous. It is worthy of mention also that he felt obliged to limit the supply of liquid in his diet. This treatment found its most thorough expression in the 'Method of Harvey,' published by Banting,[2] according to which the diet of the patient was made up as follows:—

1. Morning: 120 to 150 grms. (4 to 5 oz.)[3] of meat or fish (bacon and salmon excepted); tea without milk or sugar; 30 grms. (1 oz.) of dry toast.

2. Mid-day: 150 to 180 grms. (5 to 6 oz.) of meat; some vegetables, excluding potatoes; 30 grms. (1 oz.) of dry toast; 2 to 3 glasses of Burgundy or sherry. No pastry nor pudding; no champagne, port, nor beer.

3. Afternoon: 60 to 100 grms. (2 to $3\frac{1}{2}$ oz.) of fruit; a biscuit or two; tea.

4. Evening: 100 to 120 grms. ($3\frac{1}{2}$ to 4 oz.) of meat or fish; 1 or 2 glasses of Burgundy.

No restriction is placed on the supply of water.

By rigidly adhering to this diet, Banting reduced his weight from 183 to 151 lbs. in nine months, *i.e.* nearly a pound a week, and lessened his girth by $12\frac{1}{4}$ inches.

Vogel's [4] modification of this diet, more adapted to the German mode of life, runs as follows:—

1. Breakfast: Coffee without milk or sugar, or very little of these; some dry toast, or biscuit; no butter nor fancy bread.

2. Second breakfast for large eaters: Two soft eggs, lean

[1] Dr. Th. K. Chambers, *Lectures*, p. 542. London, 1864.
[2] W. Banting, *Letter on Corpulence, addressed to the Public.* London, 1864.
[3] The equivalent English weights are in round numbers.—Translator.
[4] J. Vogel, *Corpulenz: ihre Ursachen, Verhütung und Heilung.* 5th edit. Leipzig, 1865.

raw ham, or other lean meat; a cup of tea, or a glass of light dry wine.

3. Mid-day meal: A plate of thin meat soup, lean meat—boiled or roast, greens or 'compot,' a potato or two, and a little bread.

4. Afternoon: Black coffee.

5. Evening: Meat soup or tea with cold meat, lean ham, soft eggs, salad, and a little bread.

Each of the above diets, and especially the English, is distinguished by the predominance of nitrogenous food; and since they have been followed by a considerable reduction of obesity in all cases observed hitherto, according to the length of time the regimen has been in force, there is nothing to be said against the method in its chief feature, the reduction of fat by an abundant supply of nitrogen. But amongst the numerous experiences of this diet since Banting's publication there have occurred a number of cases where, after perseverance with the diet for some time, although the patients certainly lost weight, they became at last so weak and low, so nervous and sleepless, that suspension of the treatment was necessary. In other cases the unrestricted flesh diet caused dyspepsia with gastric and intestinal catarrh.

Before we deal, therefore, with the composition of a suitable diet, it will be necessary to have a clear idea of the effect of a large supply of nitrogen upon tissue-change. By a better knowledge of the processes here occurring we shall be able to define more accurately the conditions for a large albuminous supply in persons suffering from the forms of obesity indicated, without injury to the health.

a. The Destruction of Albumen supplied in the Food.

According to the investigations of Bischoff and Voit [1] the conversion of albumen within the body increases as a rule with an increased albumen-supply.

If only as much albumen be afforded as is decomposed in the fasting state, the body is not satisfied; its albuminous excretion is somewhat smaller, but there is increased destruction.

[1] V. Voit, 'Physiologie des allg. Stoffwechsels u. der Ernährung,' Hermann's *Handb. der Physiologie*, vol. vi. part i. p. 106. Leipzig, 1881.

If the albumen-supply be raised, the loss of albumen from the tissues of the body becomes smaller and smaller, under increased assimilation of albumen, till finally the albumen-destruction equals the supply, and a stable condition is reached, for the amount afforded in the food.

V. Voit gives us the following figures:—

Flesh-supply in grms.	Flesh-destruction	Gain or loss of flesh to the body
—	223	−223
—	190	−190
300	379	− 79
600	665	− 67
900	941	− 41
1,200	1,180	+ 20
1,500	1,446	+ 54
—	190	−190
250	341	− 91
350	411	− 61
400	454	− 54
450	471	− 21
480	492	− 12

Further, by the supply of albumen a certain condition is induced in the body upon which the amount of its albumen-consumption depends. If the same supply be continued for a long period, under certain conditions as much albumen may be destroyed as is introduced. With a varying supply of albumen, on the other hand, its destruction within the body shows a tendency to approximate the destruction caused by the immediately preceding supply. Experiments on feeding dogs with flesh-meat give the following results:—[1]

Flesh-meat consumed, in grms.	Flesh-conversion	Gain or loss to the body	Previous food supply?
1,500	1,599	− 99	2,000 grms. flesh-meat
1,500	1,467	+ 33	1,500 „ „
1,500	1,267	+233	Fasting
1,500	1,186	+314	Food poor in nitrogen

According to the results of these and similar experiments of Voit, a certain condition of the body results from the supply

[1] V. Voit and others. See also J. Forster, 'Ernährung und Nahrungsmittel,' v. Pettenkofer and v. Ziemssen's *Handb. der Hygiene*, part i. sect. i. p. 31. Leipzig, 1882.

of albumen, *i.e.* a certain relation of the quantity of easily destroyed albumen to the entire organism. If this condition is to last a given time, then exactly as much albumen must be supplied throughout as is destroyed in the body. The 'albuminous condition' induced by a rich albumen-supply can only be maintained by large quantities of albumen persistently supplied. But since with the albumen-supply the albumen-destruction continually rises up to high limits, we should finally require enormous quantities to prevent loss of albumen from the body. But the degree of accumulation of albumen within the body is limited, apart from the readily induced feeling of satiety, by the small capacity of the intestinal tract for its digestion and absorption. Even the carnivora cannot go beyond certain limits, according to Voit's experiments. While a strong dog could consume and digest up to 2,500 grms. of flesh-meat daily (containing about 500 grms. of albumen), vomiting and diarrhœa resulted after larger quantities. If too little albumen be taken, the stable material of the tissues itself diminishes, without finding an equivalent in the food, and this minus quantity is made apparent by the fact that for a long time more nitrogen is excreted than is contained in the food; the so called 'nitrogenous balance'—to obtain which a much larger supply of albumen is required than is excreted in the fasting state—is absent.

With the exclusive use of albumen-stuffs, that condition in which no more albumen is destroyed within the body than is supplied in the food is only reached when the amount supplied approximates (in man, perhaps, exceeds) the quantity which can be absorbed from the intestine in a given time.

Since, then, in spite of a rich albumen-supply alone, an individual ultimately needs more than is supplied, the albuminous condition above mentioned cannot be obtained in this way, *i.e.* only by the use of inordinate quantities of albumen. Rubner[1] consumed for several days over 1,400 grms. of flesh-meat without being able to maintain the albuminous condition even for two days together. The relations are more favourable in the cases which especially interest us here. According to Voit's

[1] Rubner, *Zeitschr. für Biologie*, vol. xv. p. 115, 1879.

investigations,[1] the smallest quantity of pure albumen sufficient for the nitrogenous balance depends *not alone on the amount of albumen in the body, but also on its fat.*

An organism rich in fat requires less albumen for that end, inasmuch as it uses up a smaller quantity of the latter, even when fasting. Young animals poor in fat need far more albumen than older and fatter ones, who quickly attain a nitrogenous balance.

On these grounds, fat persons more easily take up the albumen necessary for the maintenance of the albuminous state than thin persons, in whom, in spite of an abundant supply of albumen, there is destruction of the albuminous constituents of the tissues of the body. But that a limit to their consumption of albumen is easily reached is proved by those cases in which, on the one hand, after large supplies of albumen disorders of digestion frequently occur, the intestine being no longer able to digest the amount of albumen necessary for the albuminous condition; on the other hand, with an insufficient supply of albumen, although the patients become poorer in fat they fall off also from their albuminous condition more or less, and rapidly feel weak and miserable.

Very different from the albumen-conversion is the behaviour of the *fat-conversion* in the living body. If *less* fat (or carbohydrates) be taken than is oxidised in the fasting condition, fat will still be given up from the fat stores of the body; but if *more* fat (or carbohydrates) be consumed than is required to satisfy hunger, then with increased supply of food, although somewhat more fat is indeed used up in the body, the greater part of the excess supplied on any one day over the quantity destroyed that day remains in the body, and is deposited in its fat-reservoirs.

b. Albumen-Destruction in Presence of Fat.

While albumen or nitrogenous foods nearly allied to it can alone replace albumen, fat can be replaced by albumen and its allies, according to the experiments of Pettenkofer and Voit.[2]

[1] V. Voit, *op. cit.* p. 113.

[2] Pettenkofer and Voit, *Zeitschr. für Biologie*, vol. vii. p. 433, 1871.

By the use of large quantities of albumen, differing in different people, a condition occurs by-and-by in which no more nitrogen is excreted per diem, and also no more carbon, than is taken in the food in the same time—that is to say, under the influence of an exclusively albuminous supply, the loss both of albumen and fat is covered. If the supply of albumen be increased still further, some portion of the carbon and hydrogen therein contained is unoxidised, and remains in the body as fat. In a dog weighing about thirty kilogrammes, Pettenkofer and Voit obtained these values for the conversion, in grammes:—

Flesh meat		Flesh-conversion	Fat-conversion	Oxygen used up
Consumed	Destroyed	In the body		
—	165	−165	−95	330
500	599	− 99	−47	341
1,000	1,079	− 79	−19	453
1,500	1,500	—	+ 4	487
1,800	1,757	+ 43	+ 1	—
2,000	2,044	− 44	+58	517
2,500	2,512	− 12	+57	—

The influence of a rich albumen-supply on fat-deposition and fat-consumption is strikingly different in lean and fat bodies respectively. Whilst under similar conditions and with an equal supply of albumen, supposing it to be sufficient, fat accumulates in the lean body, the fat one loses some of its deposited fat and becomes thinner, like those nourished on the Harvey-Banting method.

In four successive experiments on the same animal, who took 1,500 grms. of flesh meat. Pettenkofer and Voit found the flesh- and fat-conversion to be as follows:—

No.	Flesh destroyed	Gain or loss to the body		Condition of the animal
		Fat	Flesh	
1	1,450	+50	− 7	Fat
2	1,506	− 6	− 5	"
3	1,476	+24	+ 7	Moderately fat
4	1,420	+80	+23	Lean

These experiments especially indicate that, besides the

general condition in which fatty deposition on the animal organism is dependent, the varying condition of those cells which can store up fat in greater quantity is also of importance.

Finally the influence of fat upon tissue-change is especially important for our problem, in the first place, because a supply of fat in the food retards any loss of albumen that would otherwise occur, and limits the destruction of albumen generally, thus facilitating an *albumen-accumulation* in the body ;[1] and, secondly, because when fat and albumen are both given, a balance between the albumen supplied and that destroyed arises sooner than with the use of albumen alone—that is to say, *with a relatively small albumen-supply no more albumen is used up in the body than is contained in the food.* Thus, in dogs that still excreted albumen when taking 1,200 grms. of flesh meat daily, the nitrogenous balance was established on giving them 500 to 600 grms. of flesh-meat and 200 grms. of fat. Experiments on men have given similar results.

If more fat be supplied than is necessary for the requirements of the body, it remains in the body and is stored up as fat. The most certain proof of the transition of fat absorbed from the food into the fat stores of the body is shown by the fact that varieties of fat which are foreign to the normal body become deposited in it when supplied in quantity. Radziejewsky and Ssubotin were unable to show this, but Lebedeff[2] did so by letting two dogs starve till all the spare fat of the body was used up, and then feeding one of them with linseed oil, the other with mutton suet, giving in either case as little albumen as possible. After three weeks they both became fat, and the fat of each dog did not differ essentially in its properties from the kind supplied. The fat of the dog fed on linseed oil contained an oil not solidifying at 32° F., while the fat of the dog fed on mutton suet had a much higher melting-point than the normal fat of dogs.

[1] Bischoff, *Der Harnstoff als Maass des Stoffwechsels*, p. 143, Giessen, 1853 ; Botkin, *Arch. f. path. Anat.*, xv. p. 380, 1858 ; Bischoff and Voit, *Die Gesetze der Ernährung des Fleischfressers*, p. 97, 1860 ; Voit, *Zeitschrift für Biologie*, vol. v. p. 329, 1869

[2] Dr. A. Lebedeff, 'Ueber die Ernährung mit Fett,' *Zeitschrift f. physiol. Chemie*, vol. vi. p. 1039 : 'Ueber Fettansatz im Thierkörper,' *Centralblatt für med. Wissensch.*, No. 8, 1882.

c. Albumen-Destruction in Presence of Carbohydrates.

The carbohydrates also (starches, dextrin, sugars, gums, and allied proteins) exert the same influence as fat upon albumen-conversion. Like fat, they exert a saving influence upon the latter, without preventing its waste altogether, and these two kinds of food, fat and carbohydrates, are thus related not only qualitatively but quantitatively.

According to Voit's results, about the same amount of albumen is protected from destruction whether fat or carbohydrates be given in equal weights. There is a slight increase of albumen-conversion on taking a large quantity of fat only, so that in this respect the carbohydrates seem to act the more favourably of the two.

Voit's experiments give the following, in grms.:—[1]

Food		Flesh conversion
Flesh meat	Non-nitrogenous food	
500	250 fat	558
500	300 sugar	466
500	200 ,,	505
800	250 starch-stuffs	745
800	200 fat	773
2,000	200–300 starch-stuffs	1,792
2,000	250 fat	1,883

It is evident from these experiments that there is less decomposition of albumen when carbohydrates are taken than with an equal amount of fat.

The carbohydrates when taken in excess are quickly destroyed in pretty large quantity, and perhaps only when in great excess are they in part converted into fat. They thus behave very differently from fat, of which only a certain quantity is oxidised in the body, while any excess in the supply tends to its accumulation. Like fat they save albumen, and not only so, but fat itself is saved by them, and therefore they may be taken instead of fat with equal results. Since the animal organism, with a rich supply of carbohydrates, excretes more or less the quantity of carbon corresponding to them, we may hence conclude that in this case no fat accrues to the body.

[1] Voit, *Physiologie des Stoffwechsels*, p. 143.

In regard to the question whether carbohydrates can be turned into fat (Liebig), the researches of Pettenkofer and Voit[1] show that in feeding with flesh-meat and carbohydrates, the quantity of carbon that can remain in the body is not rendered greater when more and more carbohydrates are given; but the supply of carbohydrates remaining the same, less carbon accumulates in the body when less albumen is destroyed, and *vice versâ*.

EXPERIMENTS ON FEEDING WITH CARBOHYDRATES.

	Supply		Flesh-conversion	Starch-stuffs destroyed	Fat deposited in the body
	Flesh-meat	Starch-stuff			
I. 1	—	379	211	379	+ 24
2	800	379	608	379	+ 55
3	1,800	379	1,469	379	+ 112
II. 1	—	379	211	379	+ 24
2	—	608	193	608	+ 22

It may be seen from these results, that either the chemical material of fat-formation is wholly or partly supplied by the decomposed albumen-molecules in presence of carbohydrates, or else the mechanical conditions for the conversion of carbohydrates into fat occur only at the moment of destruction of an albumen-molecule.

d. ALBUMEN-DESTRUCTION DURING WORK.

As the albumen-destruction differs from the fat-destruction during fasting and rest, so it differs during work (in particular, muscular work), and the influence which this exerts upon tissue-change is of special importance, according to the standpoint we have gained in the treatment of stasis in the vascular apparatus.

While Liebig[2] sought for the force underlying muscular work in the destruction of albumen forming muscular tissue, Voit has shown[3] that neither in animals nor in man[4] is albumen-

[1] Voit, *op. cit.* p. 252 *et seq.*

[2] Liebig, *Sitzungsber. d. bayr. Acad.*, ii. p. 363, 1869; *Annalen d. Chemie u. Pharm.*, cliii. pp. 1, 137.

[3] Voit, *Ueber den Einfluss des Kochsalzes, Kaffees u. der Muskelbewegung auf den Stoffwechsel.* Munich, 1860.

[4] Pettenkofer and Voit, *Zeitschr. für Biologie*, vol. ii. p. 543.

destruction increased by very severe bodily activity if sufficient non-nitrogenous food be given; only when the exertion is so strenuous that dyspnœa arises (Oppenheim [1]) is there a slight increase of albumen-destruction, and the dyspnœa causes this from want of oxygen, just as when carbonic acid is breathed, or an atmosphere deficient in oxygen (Fränkel [2]).

On the contrary, there are conditions underlying muscular function which, owing to the fact that activity induces hypertrophy of muscle, and therefore an increase of its substance, lead to deposition or storing up of albumen in the muscular elements. From the relations of these latter we must draw the conclusion, important for us, that even if muscular work is not directly connected with albumen-destruction and causes no increase of it, yet the need for albumen in the active body must be somewhat higher (according to the amount of muscle engaged) than during rest. We shall have to bear in mind these facts when we attempt to strengthen a weak atrophied muscle by increased function.

In contrast to albumen-destruction, fat-destruction is considerably increased by work. The experiments establishing these processes in every detail were carried out by Pettenkofer and Voit on men under the ordinary conditions of life, and the following tissue-changes occurred after 8 to 10 hours of work, expressed in grammes, and calculated for 24 hours:—

	Flesh-conversion	Flesh, gain or loss to body	Fat-conversion	Fat, gain or loss to body	Carbohydrates destroyed	Carbohydrates excreted
I. *Fasting:*						
Rest . .	333	−333	216	−216	—	738
Work .	311	−311	380	−380	—	1,187
II. *Moderate diet:*						
Rest . .	568	—	72	+ 54	352	912
Work .	567	+ 1	173	− 56	352	1,209

The observations of Fick and Wislicenus [3] also are of interest

[1] Oppenheim, *Pflüger's Archiv*, vol. xxiii. 1880.
[2] Fränkel, *Virchow's Archiv*, vol. lxvii. 1876.
[3] Fick and Wislicenus, *Vierteljahresschrift der Züricher Naturf.-Ges.*, vol. x. p. 317.

here. They both ascended the Faulhorn on a non-nitrogenous diet, and determined the amount of albumen-destruction during the expedition. It was shown that the heat derived from oxidation (which heat Frankland sets down to albumen-destruction [1]) was insufficient for the mechanical equivalent of the work done in raising the body the height ascended. They therefore assumed that part of this force was afforded by the combustion of non-nitrogenous material.

With a sufficient supply of albumen, the fat-condition of a working individual can be maintained only when as much fat (or carbohydrates) is provided as is used up in the body during work. If only as much fat be supplied as just suffices to maintain the fat-condition during rest, the fat stores of the body will evidently diminish during work; and if the insufficiency of fat and carbohydrates in the food persist long, there will be fat-wasting. But as soon as this begins, the albumen-destruction will rise. The fat supplied no longer suffices to maintain the albuminous condition; there is now *albumen-wasting*.

Reviewing these facts, we find, then, that a supply of fat is important for the preservation of the albumen-condition during muscular work, and the greater the latter becomes so much the more fat and carbohydrates must be added to the diet if albuminous loss is to be avoided, as is especially the case with the patients we are considering.

Application of the Laws of Nutrition to Methods of Fat-Reduction.

EXAMINATION.

There can be no doubt that these nutritive laws, established by repeated experiments, are of extreme importance in the projection of any dietetic plan for overcoming obesity; but to what degree they are to influence our method—whether they are to govern it altogether or to occupy only a secondary *rôle*—will be determined by a number of disturbing elements in the question.

[1] Frankland, *Philosoph. Magaz.*, vol. xxxii. 1866. See also Danilewski, *Med. Centralbl.*, 1881, pp. 465, 486.

The commonest method of fat-reduction, which obtained its full expression in the Harvey-Banting procedure, is founded on the physiological fact that, when fat persons are fed upon large quantities of nitrogenous food, with exclusion or great deficiency of fat and carbohydrates, the deposited fat is gradually used up.

A modification of this method has been recently published by Ebstein,[1] who bases his diet (as he states) upon Voit's investigations. Ebstein gathers from these that by giving *fat* fat-deposition in the body is retarded, but that the *carbohydrates*, on the other hand, would favour fat-formation out of the products of albumen-destruction. These assumptions are not to be deduced from Voit's experiments.

Both carbohydrates and fat, if not taken immoderately, are oxidised to form carbonic acid and water, just like the non-nitrogenous part of the products of albumen-destruction.

As we have seen from the investigations of Pettenkofer and Voit, the influence of carbohydrates upon fat-combustion is the same in kind as that of fat; the distinction is merely quantitative. In the same animal, the following figures were obtained, reckoned from the nitrogen and carbon excretions in grms.:—

Food supplied		Flesh-conversion	Carbohydrates destroyed	Fat destroyed	Fat deposited in the body
400 flesh-meat	344 starch-stuffs	413	344	—	+45
400 ,,	200 fat	450	—	159	+41

These experiments show that, with the same albumen-conversion, the fat deposited was the same when 344 grms. of carbohydrates were given as when 200 grms. of fat were given.

As we have seen from Voit's experiments, if too much carbohydrates be given, they doubtless form carbonic acid and water; but non-nitrogenous products of albumen-destruction will be deposited as fat in the body, and none of the fat already present will be used up. Again, if fat be given in large quantities, part of it similarly forms carbonic acid and water by oxidation, and the body fat is spared as before; on the other hand, the excess, the portion of fat not required for heat and

[1] W. Ebstein, *Die Fettleibigkeit und ihre Behandlung.* Wiesbaden, 1882.

work, is simply deposited as such (Lebedeff). Fat, therefore, favours fat-deposition to a far higher degree than carbohydrates, since at least the greater part of an excess of these is converted into carbonic acid and water.

It is not, therefore, a matter of indifference which we give, fat or carbohydrates, but the use of the latter in equivalent amount to fat will be less favourable to fat-formation than if fat itself be given, and the chief advantage of the method lies in its avoiding as far as possible the disadvantages of a purely albuminous food, *i.e.* it limits the albumen-destruction which follows a rich albumen-supply, and in this way favours the deposition of organised albumen, *i.e.* flesh-formation.

The diet which Ebstein arranged for a man aged 44 in fair health, and which he afterwards made the basis of his system, is as follows:

1. Breakfast: One large cup of strong tea (about 250 c.cm.), without milk or sugar; 50 grms. of bread or dry toast, with plenty of butter. (In winter at 7.30, in summer at 6 or 6.30 A.M.)

2. Dinner: Between 2 and 2.30 P.M. Soup (often with bone-marrow); 120 to 180 grms. of flesh-meat, roast or boiled, with fat gravy (fat meat preferred); vegetables in moderate quantity, the leguminous kinds being preferred, but cabbages also allowed; turnips, beet, &c., almost excluded on account of their sugar, potatoes altogether. After dinner some fresh fruit if obtainable, or a salad, or occasionally some stewed fruit without sugar.

As drink, two to three glasses of light white wine. During the afternoon, a large cup of tea without milk or sugar.

3. Evening, 7.30 to 8 P.M.: One large cup of tea without milk or sugar, in winter almost daily, in summer occasionally. An egg, or some fat roast meat, or both, or some fat ham, or sausages, or smoked or fresh fish; about 30 grms. of white bread with plenty of butter; occasionally a little cheese and some fresh fruit.

If Ebstein was able to make this man thinner on the above diet, it can only be explained by supposing that the fat supplied was insufficient in itself to cover the combustion of non-nitrogenous matter in the body, and hence that, besides the non-

nitrogenous portion of the albumen supplied, a part also of the body-fat was destroyed. On the other hand, if the fat-supply had been only a little larger, fat-deposition would have resulted just as after an excess of carbohydrates. Ebstein might have replaced some or all of the fat by carbohydrates without harm to his results. One advantage of this method, as Ebstein emphasises, is that by it a variety is introduced into the diet, and that it does not produce gastric disorder, as the Banting 'cure' does sometimes. To this it may be answered that many people, again, are easily disgusted with fat, and to compel such people to take much fat would only induce dyspepsia, going on to total anorexia and more or less obstinate gastric catarrh. Therefore on this point the value of Ebstein's method is illusory.

The Harvey-Banting method (and in part Ebstein's modification of it) presupposes certain conditions in the physiological functions of the affected organism, which conditions must be present if any result is to be attained. In order to reduce obesity by this method it will be essential—

1. That an albumen-supply be given far beyond what is required in the fasting condition—exceeding it fourfold—if the body is not to lose in albumen instead of fat.

2. That in order that so large a quantity of albumen may be digested and absorbed from the intestine, a powerful digestive ferment for albumen must be secreted. When this ferment is insufficient, as after previous insufficiency of albumen or in spanæmia or hydræmia, the albuminous mass will not be prepared for absorption, but will remain more or less dissolved in the stomach and intestine, and will cause dyspeptic troubles or gastric and intestinal catarrh.

We find ourselves in this dilemma, that the formation of a nitrogenous digestive ferment depends on a highly nitrogenous diet, while the latter, again, requires the presence of the ferment. We must, therefore, avoid everything which may injure the quality of this ferment, especially diluents, and *at meal-times* a limitation of or complete *abstention from liquids must be ordered*, according to the particular case.

3. The albumen which is thus carried in large quantities into the blood must be destroyed, so that after it has split up

into a nitrogenous and a non-nitrogenous part (Voit), the latter may be completely oxidised to carbonic acid and water, and not be deposited as fat. For this it is indispensable—

a. That the *cellular activity*, on which the destruction of nitrogenous and non-nitrogenous matter depends, be perfect:

That the muscular exercise do not go on so far as to cause dyspnœa. For the muscular work, especially locomotion, would be limited by this, or reduced to such a minimum that the combustion of the non-nitrogenous parts of the food would be lowered, and the formation of a relative excess of these would be induced, even with a small supply:

That the blood be rich in red blood corpuscles, in order that enough oxygen may be taken up, and thereby the cellular activity on the one hand and muscular work on the other be increased, with the result of a perfect destruction of the non-nitrogenous products of albumen-decomposition.

b. But the fulfilment of these conditions is inseparably connected with the *sufficiency of the respiratory surface* to expose the red blood corpuscles to the action of the inspired air. This, again, is only possible when the blood (rich in hæmoglobin) which flows into the right heart passes on without stagnating into the lungs, and thence, oxyhæmoglobin being formed, through the left heart and arteries to the capillaries, where it can give up its oxygen to the tissues.

For the realisation of this the blood must be normal, or nearly so, and the vascular apparatus and circulation uninjured, conditions unfortunately not often met with in the cases here considered. These and similar methods are therefore only appropriate in those forms of obesity which are *simply plethoric*, while cases which, though there is neither evident anæmia nor hydræmia, yet show a transition to these conditions, become deranged, as above said, in the supply of large quantities of pure albumen.

Very differently must those cases be treated in which there exist, not only a fatty heart, relative deficiency of hæmoglobin, and serous plethora, but already more or less cardiac insufficiency, a deranged hydrostatic balance, and hydræmia.

These cases may moreover be thus distinguished:—In the first category there is *no anomaly of the vascular apparatus*,

at least previous to the development of obesity; in the second, considerable *vascular derangement already exists*, and has induced compensatory alterations.

In relation to the treatment of excess of fat, these two categories can be only partially and slowly distinguished the one from the other, whilst in both the circulating disorder governs the situation, and causes the pressing character of the separate indications. *Prognostically* considered, on the other hand, the first group is the more favourable (*i.e.* with no previous lesion), for it permits a perfect cure, while in the other group a return to the previous compensation is the most we can effect.

In both, the danger to the patient depends on the amount of derangement which the hydrostatic balance in the circulation has already suffered owing to the anæmia and hydræmia; and although the gradual accumulation of fat has partly caused, partly facilitated, these conditions, it will still be a question whether a reduction of fat will improve the patient's position.

MEANS OF FAT-REDUCTION IN CIRCULATORY DERANGEMENTS.

The treatment of obesity differs according as circulating disorders are present or not. While in the latter case the health may be restored perfectly and quickly, in the former the derangements constituting the real danger are left unaltered.

The most important organ of the circulation amenable to treatment is the heart. According to the amount of fat-accumulation in the body, the heart muscle is everywhere, or nearly everywhere, invested with a thick layer of fat, not only superficially, but extending from the pericardial tissue and the vessels between the muscular fibres. These are compressed and atrophied, so that more or less muscular tissue is destroyed. When the fatty infiltration is extensive, we often find some bundles of atrophied and degenerated muscular fibres, enclosed in a mass of fatty tissue.

Even if we were deprived of numerous actual observations, it would be easy to estimate the result of a general reduction

of obesity upon the circulating apparatus in the cases which come before us.

If the attempt to reduce the fat in the various deposits where it is stored up be successful, then the fat is removed more or less also from the heart, both that which is deposited in the enveloping pericardial tissue, and that which has accumulated between the muscular bundles, and has caused their partial degeneration. But with this reduction the patient's danger is not lessened in an equal degree. The heart does not gain in functional capacity in proportion to the decrease of fat, but, on the contrary, the more thoroughly the fat-reduction has been carried out and the greater the albumen-destruction, so much the weaker, more atrophied, and more inefficient is the heart itself left. Such a heart is less capable than ever of overcoming the stagnant watery blood in the right ventricle, and cardiac paralysis and dropsy will usher in death sooner than if the obesity had been left untouched.

Accordingly it is clear that where circulatory disorders are already present we must reject every method of reducing fat which only does this and nothing more, and our conditions may be formulated thus :—

1. The quantity of fluid in the body must be reduced, and the heart's work must be lessened, before commencing any method of fat-reduction, or at least hand in hand with such method.

2. The heart-muscle itself must be strengthened, and previous compensatory hypertrophies must be re-established.

But the former of these indications perfectly coincides with those resulting from the circulatory disorder itself, and the dietetic regimen, in which, owing to the anæmia and hydræmia, no increase of albumen-destruction can be permitted, must be an appropriate one.

For the fulfilment of the first task we shall have to select one of the methods above given for lessening the body fluids, so that, by lessening the supply of water to the system and at the same time increasing its excretion, we may effect an unloading of the venous apparatus, and enable the heart to drive onward the blood.

The second problem, the strengthening of the heart-muscle,

will be dealt with, on the other hand, by exciting powerful contractions, as already indicated (cardiac gymnastic) most effective when caused by the ascent of elevations—in other words, mountain-climbing.

Since the severe exertion which this method entails and the temperature of the surrounding air cause a sharp excitation of the sweat-nerves and a watery loss by the skin and lungs up to two kilogrammes and more, this method will also assist in the first indication, the removal of water from the body. Where, owing to the season, weather, and locality, we cannot strengthen the heart-muscle and increase the water-excretion by the ascent of appropriate elevations, we must substitute some other method of exciting the cutaneous excretion, best by the Turkish bath, the vapour-bath, or pilocarpin injections, while long walks on the level may imperfectly replace mountain-climbing (see below, Mechanical Correction, &c.) In such cases the latter procedure must be adopted subsequently.

The Influence of Nitrogenous Foods on Fat-Reduction.

Since the force required to raise the body through a great height entails the destruction of large quantities of fat, the above exertion will also lessen the fat-accumulation, on condition only that we give less fat and carbohydrates in the food than are used up in the work done. On grounds already given, we must discard a purely nitrogenous nourishment, because, when such food is given in the quantity here necessary, it is not as a rule digested and assimilated, as already explained, but soon causes dyspepsia ; and in the next place, if less than the amount absolutely necessary be supplied, although it may far exceed the amount destroyed during hunger, it always causes increased albumen-destruction in the body. Again, it is evident, from the great deficiency of hæmoglobin, that, if large quantities of pure albumen are supplied to the blood, its non-nitrogenous constituents will not be perfectly oxidised to carbonic acid and water, and thus a good part of the nitrogenous food will be itself converted into fat, and deposited as such. But if fat and carbohydrates be taken at

the same time with the albumen, a smaller quantity of this will suffice to maintain the nitrogenous balance; and if, owing to the greater muscular activity, more non-nitrogenous substances are decomposed than are supplied as fat and carbohydrates in the food, then the remaining need for these will be satisfied from the fat deposited in the body, *i.e.* the patient's obesity will be attacked, and he will get thinner. If the fat-destruction due to severe exertion be repeated at short intervals of time, the fat-stores of the body will be encroached upon more and more, and a minimum will finally be reached, beyond which we cannot go any further. The patient will have lost his obesity, and will consider himself cured.

The diet to be supplied to patients suffering from obesity and circulatory derangement together will be about the same as that which Dr. N. found of most advantage, and which he afterwards adhered to with few modifications.

As one of the first requirements of the diet, it should contain a large amount of nitrogenous food, although fat and carbohydrates are never altogether excluded. A highly albuminous diet is necessary for this reason, to begin with, that the patients are usually very anæmic, the blood is deficient in form-elements and albumen, especially if albuminuria be present, but chiefly because the voluntary muscles and the heart-muscle are all weak and atrophied, and hence a large supply of albumen is necessary for the new formation of muscular fibre and the increase of that already present, which result from the course of exercises perfected in mountain-touring.

For the better nutrition of the vascular walls also, if their permeability has already suffered from the circulation of a watery blood, poor in albumen, and if œdematous infiltrations in the legs be present or be feared, the quantity of the *circulating albumen* must not only be kept up, but be *raised*. Therefore more albumen must be supplied in the food, and fat and carbohydrates must be given, because they lessen the destruction of albumen, and favour its conversion into organised albumen.

General directions as to the kind and quantity of albuminous food and the arrangement of meals will be given further on, but the quality must be carefully attended to, as

a successful result greatly depends on this. Since a large albuminous supply is the main indication, we must evidently give highly albuminous foods, and amongst these two are of special importance, although their usefulness has been quite recently disputed, viz. *flesh-meat* and *eggs.*

Flesh-meat must be looked upon as the most suitable food in all diseases in which there is rapid progressive nutritive disturbance and loss of strength, and against its use there are no objections founded on positive experience. It is said, indeed, that albuminuria has appeared, or existing albuminuria has been increased, after a large meal of flesh-meat. But accurate figures and exact investigations are wanting to justify an assumption of such importance to the patient. (See below, D, Investigations on Albumen-Excretion.)

Physiological experiments directly contradict the assertion that, after a large supply of flesh-meat, albumen is excreted in the urine. Neither Pettenkofer nor Voit, nor any other investigator whose works on tissue-change and nutrition have become standard, have made any such observation, either on animals or man; and we must firmly maintain, on laws based on hundreds of experiments, that flesh-meat introduced into the body is partly changed to organised albumen, partly decomposed, and the nitrogenous products of the latter appear as urea. However large the quantity of albumen supplied it was always found to behave thus, and albuminuria was never observed after the ingestion of large amounts of albumen.

A dog weighing 35 kilos., belonging to Voit, ate 2,600 grms. of pure flesh-meat in 24 hours without showing a trace of albuminuria, and yet the proportionate amount for a man weighing 70 kilos. would be not less than 5·2 kilos. of flesh-meat. Another ravenous *Dachshund* of only 7·4 kilos. in weight, that I made use of in other experiments to be mentioned presently, took 600 grms. in 24 hours, a quantity equal to 6 kilos. for a man weighing 74 kilos., without the appearance of any albumen in the urine.

Calculating the amount of albumen consumed by these two dogs, and comparing it with the albumen of the blood-plasma, we obtain the following figures:—

First dog.—The plasma (1684·5 grms.) of the whole blood

(2,508 grms.) contained 78·834 grms. of dry albumen; and in the 2,600 grms. of flesh-meat which he consumed there were 468 grms. of dry albumen (18 per cent.), *i.e.* 5·9 times as much within 24 hours as was contained in the blood-plasma.

Second dog.—The plasma (371·2 grms.) of the whole blood (551 grms.) contained 173 grms. of dry albumen, and in the 600 grms. of flesh-meat which he ate there were 108 grms. of dry albumen, *i.e.* 6·2 times as much within 24 hours as was contained in the blood-plasma.

In spite of these large quantities of albumen, which certainly constituted an excess in the blood of each dog, owing to the *regulatory activity* of the kidneys no albumen was found in in the urine, but the whole was destroyed within the body in the way already pointed out.

But even when albuminuria is already present, it has not been shown by exact investigations that its occasional increase under a flesh-diet is solely due to the increased albumen-supply, and not rather to other causes, or indeed to the disease itself. Observations on this point, however, are too few and incomplete, and the experiments detailed below show us how careful we ought to be in drawing rash conclusions from single cases.

Although Lichtheim has pointed out that in cases of albuminuria a very albuminous diet may give rise to a larger quantity of urea in the blood than the kidneys can excrete, and hence that uræmic symptoms may arise, this is only to be feared in cases of advanced kidney disease, in which the treatment has to be confined to palliative measures, or where in intercurrent acute inflammation or chronic processes the diet depends altogether on the symptoms present.

Christison states that he observed an increase of an existing albuminuria after the use of *cheese*, but without adducing any large number of experiments or quantitative values, so that nothing can be gathered from his statement.

After the above experiments on flesh-feeding I deemed it superfluous to prove by fresh experiments that the ingestion of the largest quantities of flesh-meat, and the passage into the blood of an amount of albumen far exceeding the normal, will not cause the transudation of any of it through the renal capillaries. I could not convince myself that even an existing

albuminuria was perceptibly increased by the supply of large quantities of flesh-meat, and that any occasional slight increase was not due to an increase of the pathological processes going on in the kidneys. We shall return to this question later on.

It is otherwise with the theory of the harmfulness of egg-albumen. This theory possesses a certain basis from experiments on animals, and though no special weight as regards man is to be attached to these observations (which, moreover, are lacking in quantitative precision), yet these animal experiments are trumped up on the most varied occasions, or else new hypotheses are deduced from them.

The importance of eggs in nutrition generally, and especially in the cases we are here speaking of, is too great to permit us to deal with it in any other way than by its thorough examination and subjection to fresh experiments.

EXPERIMENTS ON EGG-FEEDING.

It is asserted by many that egg-albumen easily passes into the urine, not only when injected into the blood, but when taken uncooked into the stomach, especially if large quantities be supplied. Disregarding the former method of introducing it, inasmuch as we are dealing with nutrition exclusively in these experiments, the latter becomes of great interest. If the above statement rested on fact, we should have to deprive a number of our patients of a food of high nutritive value, and a food which badly nourished or hydræmic patients would sadly miss.

Besides earlier observers (Tégart [1] and Brown-Séquard [2]), Becquerel [3] has stated that Barreswil had albuminuria himself for twenty-four hours after taking ten eggs, and Hammond [4] says that he made a similar observation on himself. Claude Bernard [5] also adopts the view that egg-albumen passes directly from the stomach into the blood. Stokvis [6] observed albuminuria after feeding exclusively with egg-albumen for several days, and in the rabbit earlier

[1] Tégart, *Thèse.* Paris, 1845.

[2] Brown-Séquard in Tessier's *Thèse sur l'Urémie.* Paris, 1856.

[3] Becquerel and Barreswil, *Union Médicale*, No. 144.

[4] Hammond, *Journ. de Physiologie*, 1848, p. 416.

[5] Cl. Bernard, *Leçons sur les Propriétés Physiologiques et les Altérations Pathologiques des Liquides de l'Organisme*, ii. 5me leçon, 1859.

[6] B. J. Stokvis, *Recherches Expérimentales sur les Conditions Pathologiques de l'Albuminurie.* Brussels, 1867.

than in the dog. The former began to excrete albumen on the sixth or seventh day, and then chiefly about five to six hours after feeding. J. Lehmann [1] repeated the experiments of Stokvis in the following manner. He gave a dog at one meal a large quantity of egg-albumen, but after seven ounces were given there was only a faint trace of albumen in the urine, usually on the second day. An accurate statement of the quantity excreted by the animal in twenty-four hours is nowhere to be found. Finally, Beneke [2] thought he could confirm the above results, in so far that on one or two occasions he found small quantities of albumen in the urine after large meals of flesh-meat. (Compare D, Investigations on Albumen-Excretion in Healthy Persons.)

Coagulated albumen, according to Stokvis, behaves differently from fluid albumen. In two experiments on rabbits, when he injected coagulated albumen into the stomach there was no albuminuria; and he concludes that of the dissolved albumen introduced into the stomach part is absorbed as such without being converted into peptone, while coagulated albumen cannot be absorbed as such.

On the basis of these investigations, Senator [3] declares that when albuminuria already exists eggs should be proscribed entirely, and flesh-meat restricted as far as possible. But since the patient is not to be deprived of meat altogether, those kinds of flesh which are poor in albumen are to be preferred, such as veal and fowls (so called 'white meat'). Fish also, which is poorer than beef in albumen, may be allowed to a certain extent. On the other hand, vegetables may be used largely, though even here those sorts which are poor in albumen—*e.g.* green vegetables, salad, fruit, &c.—are to be preferred to the more albuminous kinds, especially the leguminous. Senator chiefly recommends an exclusive milk diet, and says that milk may be taken up to two litres daily—a quantity that would be disastrous for our patients—or, instead of milk, milk soups with the addition of carbohydrates (flour stuffs), in order to make up the necessary quantity of these. Such a 'milk cure' is declared by Senator to be well tolerated for weeks at a time, and to give good results, while it excellently answers the indications which he formulates for the diet in albuminuria.

The above statements show plainly enough the great practical importance of the question, both as to nutrition generally and for our

1 J. Ch. Lehmann, 'Ueber die durch Einspritzungen von Hühnereierweiss ins Blut hervorgebrachte Albuminurie,' *Virch. Archiv*, vol. xxv. parts v. vi. 1864.

2 F. W. Beneke, *Grundlinien der Pathologie des Stoffwechsels*, 1874, p. 225.

3 H. Senator, 'Ueber die hygienische Behandlung der Albuminurie,' *Berl. klin. Wochenschr.*, No. 49, 1882.

patients in particular, as suffering from circulatory derangements or already existing albuminuria.

I therefore subjected the problem to four series of experiments :

1. How does albumen behave in the half-coagulated condition in which it is usually given to patients, viz. in soft-boiled eggs?

2. How does perfectly fluid albumen behave when taken by a patient suffering from severe circulatory derangement, who has had albuminuria repeatedly, and who is still œdematous about the lower limbs?

3. Experiments on a dog, as much fluid albumen as possible being given.

4. An investigation to ascertain whether by taking large quantities of pure albumen an existing albuminuria is increased or not, and to what degree.

These experiments I considered would solve the question of the harmfulness of egg-albumen with sufficient certainty as far as the subject interests us at present.

First Series of Experiments on Egg-Feeding.

In order to ascertain whether half-coagulated albumen when eaten is wholly or partly excreted by the kidneys, I gave the patient soft-boiled eggs for several days, and tested the urine passed during the whole twenty-four hours by boiling, then by adding nitric acid, and lastly by acetic acid and potassium ferrocyanide.

A. H., a female aged 45, suffering from slight struma with cardiac hypertrophy, moderate venous stasis, severe palpitations and dyspnœa on exertion, especially when going up-stairs. No albumen in the urine.

Exp. I.—In order to commence with only as many eggs as the patient could relish, I began on June 4, 1883, with two soft-boiled eggs morning and evening, the ordinary meals being taken as usual. All the urine passed during each period of twenty-four hours was mixed together and examined as above.

June 5. Urine acid. Sp. gr. 1,023. No albumen.

Exp. II.—June 6. After four eggs

Urine acid. Sp. gr. 1,021. No albumen.

Exp. III.—June 7. After six eggs (two at breakfast two at dinner, and two at supper), besides ordinary meals :

Urine acid. Sp. gr. 1,022. No albumen.

Exp. IV.—June 8. After six eggs :

Urine acid. Sp. gr. 1,025. No albumen.

Exp. V.—June 9. After eight soft-boiled eggs the day before. The rest of the food was limited to some soup, some milk, and a small piece of veal with a little bread. The drink was light wine and water :

Urine acid. Sp. gr. 1,028. No albumen.

Exp. VI.—June 10. After eight eggs again, diet as before :

Urine acid. Sp. gr. 1,020. No albumen.

The urine was then examined daily for eight days, but without giving a trace of albumen or its connections.

It is evident from these experiments that half-coagulated albumen is perfectly destroyed in the body, and that none of it is excreted in the urine, even in patients with existing circulatory derangement (though not of high grade), and in whom the blood-pressure in the kidneys has already suffered alteration.

Second Series of Experiments.

The Ingestion of Fluid Egg-Albumen.

The person experimented upon was a man aged 58, who, in consequence of scoliosis of the upper dorsal vertebræ, had suffered for several months from severe circulatory derangements with constant suppurative dyspnœa, and some œdema was already visible about the ankles. To combat this condition the supply of fluid was very much restricted from June 1, 1883, and perspiration was induced as much as possible by walking in the open air in the hot summer weather. His weight was 49·4 kilos.

The urine was examined daily for albumen and its connections from the 1st to the 11th of June, but was never found to contain any. During this time the patient's diet was as follows, with scarcely any variation :—

Fluids.	C.cm.	*Solids.*	Grammes
Milk	130	Bread	90
Wine	260	Beef	120–145
Water	130	Vegetables	120–150
Total	520	Veal or smoked ham	50
		Tongue	70
		Salad	70
		Roll	50

This diet was scarcely varied during the whole time of experiment.

Exp. I.—June 12. On the previous day six raw eggs had been consumed—two at breakfast, two at dinner, and two at supper.

After six raw eggs:

Urine = 760 c.cm. Acid. Sp. gr. 1,027. No albumen.

Exp. II.—June 13. After eight raw eggs:

Urine = 750 c.cm. Strongly acid. Sp. gr. 1,027. No albumen.

Exp. III.—June 14. After eight raw eggs:

Urine = 780 c.cm. Strongly acid. Sp. gr. 1,026. No albumen.

Exp. IV.—June 15. After ten raw eggs, with cognac, 20 grms.

Urine = 820 c.cm. Strongly acid. Sp. gr. 1,025. No albumen.

Exp. V.—June 16. After ten raw eggs with 20 grms. of cognac:

Urine = 790 c.cm. Strongly acid. Sp. gr. 1,028. No albumen.

Exp. VI.—June 17. No eggs given, the patient being disgusted with them:

Urine = 740 c.cm. Strongly acid. Sp. gr. 1,025. No albumen.

Exp. VII.—June 18. No eggs given:

Urine = 780 c.cm. Strongly acid. Sp. gr. 1,025. No albumen

Exp. VIII.—June 19. After ten raw eggs, with 10 grms. of cognac:

Urine = 860 c.cm. Strongly acid. Sp. gr. 1,025. No albumen

Exp. IX.—June 20. No eggs given:

Urine = 800 c.cm. Strongly acid. Sp. gr. 1,025. No albumen.

Exp. X.—June 21. Ten raw eggs, in five portions, with cognac:

Urine = 820 c.cm. Strongly acid. Sp. gr. 1,026. No albumen.

Exp. XI.—June 22. No eggs given:

Urine = 760 c.cm. Strongly acid. Sp. gr. 1,023. No albumen.

Exp. XII.—June 23. Ten raw eggs, in five portions:
Urine = 840 c.cm. Strongly acid. Sp. gr. 1,023. No albumen.

After this the urine was examined daily for a fortnight, but without showing any albumen or its connections.

The patient, who suffered from severe and threatening circulatory disorder in consequence of fatty degeneration of the heart-muscle and failure of compensation, and whose kidneys had long been under the influence of venous stasis, thus took 72 raw eggs within twelve days, containing 460·8 grms. of dry albumen, besides his usual diet, without a trace of albuminuria in consequence.

His weight being 49·4 kilos., the weight of the blood may be set down as 3·8 kilos., and that of the blood-plasma (the only part coming under consideration in kidney-excretion) as 2·56 kilos., containing 119·8 grms. of dry albumen.

The patient had, then, within twelve days—

	Grammes
Dry egg-albumen	460·8
Dry blood-albumen	119·8
Dry egg-albumen	341·0

or about four times (3·9) as much egg-albumen as the albumen of his blood; while in ten eggs, containing 64 grms. of dry albumen, there was more than half the quantity of the blood-albumen.

If egg-albumen were so easily absorbed from the stomach and excreted by the kidneys, surely some albumen would have been found in the urine in this case, in which the kidneys were no longer normal owing to venous congestion. The smallest trace would have been the more apparent here because, from the small amount of fluids imbibed, the amount of urine was extremely reduced.

Third Series of Experiments.

Experiments on Animals.

These experiments were carried out in the Physiological Institute on a healthy and ravenous dog, that Professor von Voit had made use of in his nutritive experiments. The dog's weight was 7·44 kilos.

Preliminary Experiments.

To increase his greediness for food the dog was allowed to fast two days. On July 9 the urine = only 27 cubic centimetres; feebly acid. Neither boiling, nor nitric acid, nor acetic acid and potassium ferrocyanide revealed any albumen or albuminous connection in it. It should be mentioned that on boiling the filtered, highly concentrated urine a faint turbidity appeared, which disappeared both on cooling and on adding a drop of nitric acid, and which therefore was not due to albumen.

Exp. I.—July 10. The animal took:
Of lean flesh meat = 200 grms.
And the albumen of = 5 eggs.

Urine passed during July 10 and 11 = 66 c.cm. Reaction neutral. No fæces passed.

Urine analysed. Faintly acidified and boiled. No albumen.
On addition of nitric acid. No albumen.
On addition of acetic acid and potass. ferrocyanide. No albumen.

But after standing some time a slight turbidity appeared in this case.

Exp. II.—July 11. The animal again took:
Of lean meat = 200 grms.
And the albumen of = 5 eggs.

Urine = 205 c.cm. Sp. gr. 1,054. Neutral. No fæces passed.

Analysis.—The urine faintly acidified and boiled gave no albumen precipitate. With nitric acid, and also with acetic acid and potassium ferrocyanide, there was a slight turbidity after some time.

Exp. III.—July 12. Food supplied = 200 grms. of lean meat and the albumen of 5 eggs.

Fæces of semi-fluid character passed this morning.

Urine excreted July 12–13 = 222 c.cm. Sp. gr. 1,048. Reaction neutral.

Analysis.—No albumen on boiling the acidified urine. On adding a little nitric acid there was no immediate precipitate, but after standing some time a milky turbidity appeared, and small crystals were deposited at the bottom of the test-tube; the turbidity was due to excreted sulphur, the crystals to cyanuric acid. Nitric acid in excess caused an immediate crystalline precipitate of nitrate of urea. Acetic acid and potassium ferrocyanide caused slight turbidity after some time. Thus the turbidity after nitric acid was due to nitrate of urea,

and the milky turbidity in the acetic acid and ferrocyanide test was due to the precipitation of sulphur and cyanuric acid by acetic acid.

Exp. IV.—July 13. Food taken = 200 grms. of flesh meat, and the whites of 10 eggs.

A small loose defæcation this day.

Urine about 217 c.cm. Sp. gr. 1,045. Reaction neutral.

Analysis.—No albumen. The above appearances were repeated.

Exp. V.—July 14. Food taken = 200 grms. of flesh meat, and the whites of 10 eggs.

A slight defæcation this day.

Urine = 336 c.cm. Sp. gr. 1,042. Reaction neutral or feebly alkaline. No albumen.

Exp. VI.—July 15. Food taken = 200 grms. of flesh meat, and the whites of 10 eggs.

Urine = 297 c.cm. Sp. gr. 1,043. Reaction neutral or feebly alkaline. No albumen.

No fæces passed this day.

In order now to push the experiments as far as possible, and to obtain figures which should represent the limits of physiological tolerance, we endeavoured to make the dog take still more albumen, and to this end we let him fast for two days again.

Exp. VII.—July 16. No food given. No fæces passed.

Urine = 89 c.cm. Sp. gr. 1,040. Reaction neutral. No albumen in the urine.

Exp. VIII.—July 17. No food given. No fæces passed.

Urine = 56 c.cm. Reaction feebly acid. No albumen.

Exp. IX.—July 18. On this day double the usual quantity of egg-albumen was supplied, viz. *the whites of twenty eggs* = 527·5 grms. of albumen, besides the previous meat ration of 200 grms.

As the dog appeared to object to so large a quantity it was injected into his stomach. After a short time he vomited 104·4 grms. of albumen, which was not replaced by us, and he did not bring up any more. There remained, therefore, in his stomach 423·1 grms. of albumen, a quantity equivalent to 15½ eggs. All the meat was eaten. A loose evacuation of 40 or 50 c.cm. followed, and solid fæces next day.

Urine (July 18–19) = 330 c.cm. Sp. gr. 1,035. Reaction weakly alkaline. No albumen

Exp. X.—July 19. Food = 200 grms. of flesh meat.

Urine = 92 c.cm. Sp. gr. 1,039. Reaction neutral or feebly acid. No albumen.

Exp. XI.—July 20. Food = 200 grms. of flesh meat. No fæces since yesterday.

Urine = 114 c.cm. Sp. gr. 1,058. Reaction neutral. No albumen.

From these experiments we are compelled to the belief that egg-albumen, given in whatever quantity, is not normally excreted as such by the kidneys, and does not cause albuminuria. It could scarcely happen that any man could take a quantity of egg-albumen proportionate to the enormous amount consumed by this dog. His weight being only 7·4 kilos., and the albumen of ten and even of fifteen eggs having been consumed and decomposed within the twenty-four hours, a man of 74 kilos. in weight would have had to eat the whites of between a hundred and a hundred and fifty eggs in order to add a proportionate amount of albumen to his blood.

Again, since the mass of the dog's blood had a weight of 551 grms. (=7,440÷13·5), or 371·2 grms. of blood-plasma, with 17·3 grms. of dry albumen, and since he took the albumen of ten to fifteen eggs, or 35·0 grms. and 52·5 grms. of albumen respectively, he must have consumed far more egg-albumen than twice the weight of the albumen of his blood. In other words, the latter was only $\frac{3}{10}$ to $\frac{3}{7}$ of the albumen supplied to it.

Considering the enormous quantities of albumen consumed by this animal within the twenty-four hours, besides the 200 grms. of meat, the digestion and assimilation must surely have been at their greatest. Accordingly it cannot well be objected that in this particular case all the albumen was converted into peptone, while in another equally healthy animal or in man, consuming far less, the digestion is insufficient to cause its entire conversion into peptone, and that after reaching the blood it may be excreted as albumen, owing to its easy filtering capacity, or some other property, chemical or otherwise.

Moreover, nothing more can be said about the so called 'regulatory activity' of the kidneys, by which any excess of albumen in the blood is supposed to be removed more or

less quickly, because the albumen was consumed in such quantities in the above experiments that, in spite of its continuous destruction in the body, there must have been such an excess of it in the blood at some time or other as would have at once evoked the 'regulatory activity.'

There is therefore no doubt at all that in the normal condition all egg-albumen taken into the stomach, whether coagulated or fluid, undergoes destruction in the blood, so far as it is not otherwise assimilated, and that the nitrogenous part of this destruction appears in the urine in the form of urea exclusively.

Fourth Series of Experiments.

On Feeding with Egg-Albumen in existing Albuminuria.

The patient, Dr. M. H., aged 42, had suffered from albuminuria for about two years. Moderate cardiac hypertrophy, spleen enlarged to twice its size, liver normal, a few hyaline cylinders in the urine, both legs œdematous half way up to the knee. The amount of albumen was apparently never very large; the patient was fairly well nourished, and was capable of bodily and mental effort. There was no dyspnœa.

In order to judge in what quantity the egg-albumen supplied might be excreted by the kidneys, and to what extent the serum-albumen might transude beyond the usual amount, I first examined the urine for seven days, and determined the limits between which the albuminuria varied during this period. For the next ten days, I gave about ten raw eggs daily, a quantity which it will hardly ever be necessary to exceed in man. Finally, after ceasing this supply, I continued to examine the urine on the three following days, in order to ascertain whether any supplementary increased albumen-excretion had occurred.

DETERMINATION OF ALBUMEN IN THE URINE.

1. *Previous to the Egg-Feeding.*

In order to give a better insight into the patient's nutrition, and possibly to ascertain whether the variations in the albumen-excretions might depend upon the diet, especially on the flesh meat, I subjoin an accurate table of the daily diet of the patient during the whole time of experiment.

TABLE OF THE PATIENT'S DIET BEFORE COMMENCING THE EGG-FEEDING.

(In grammes.)

July	2	3	4	5	6	7[2]	8[3]
Breakfast:							
Milk-cocoa .	250	250	250	250	250[1]	250	100
Roll . .	45	45	45	45	45	45	—
Dinner:							
Soup . .	100	100	100	100	100	100	60
Beef . .	200	220	—	—	—	250	—
Veal . .	—	—	210	—	—	—	—
Fowl . .	—	—	—	½ fowl	—	—	¼ pigeon
Vegetables .	—	—	30	Strawberries	Strawberries	—	—
Pastry .	Cherry tart	—	180	—	—	—	—
Extras .	Sausage, 350	Rice broth, 600	190	Ham sandwich	Stuffed lamb's breast, 420	—	—
Bread . .	—	—	—	—	—	—	—
Supper:							
Meat . .	200	180	200	½ fowl	400	—	¼ pigeon
Salad . .	—	—	—	—	200	—	—
Extras .	—	Rice broth, 100	Macaroni, 200	Macaroni, 120	—	—	—
Bread . .	—	Cheese, 10	—	—	—	—	—

[1] One boiled egg. For drink, some light wine and ½ litre of beer, about 1,250 c.cm. in all.

[2] No evening meal taken this day. Fluids taken = 1,050 c.cm.

[3] Fluids taken = 1,100 c.cm.

TABLE OF THE AMOUNT OF ALBUMINURIA.

(Reaction of urine, acid to strongly acid throughout.)

Date	Quantity of urine in 24 hours, in c.cm.	Sp. gr.	Percentage amount of albumen	Total albumen in grammes
July 2	850	1029	0·250	2·125
„ 3	840	1028	0·302	2·536
„ 4	980	1030	0·309	3·028
„ 5	750	1033	0·406	3 045
„ 6	950	1030	0·261	2·479
„ 7	720	1029	0·336	2·419
„ 8	450	1032	0·368	1·656

Disregarding July 8, when the patient had slight sickness and diarrhœa, the albumen excreted in the urine varied between 2·125 and 3·045 grms., with a difference of 0·920. Any increase of albumen due to an egg diet must therefore, to be firmly established, exceed the larger quantity, and must reach at least 4 grms. daily. But since one egg contains 6·4 grms. of dry albumen, one might expect after from six to ten eggs (= 38 4 to 64·0 grms. of albumen) not only the above amount but a very great increase.

No cause can be assigned for the variations in the daily amount of albumen excreted, in the above table. They were certainly not dependent on variations in the diet, nor, the diet table shows, on any difference in the amount of flesh-meat. Lastly, it will be noticed that one egg (= 6·4 grms. of albumen) made no difference in the albuminuria.

2. *During the Use of Raw Eggs in the Food.*

TABLE OF THE PATIENT'S DIET WHILE TAKING FROM SIX TO TEN RAW EGGS DAILY.

(Quantities in grammes.)

July	9	10	11	12	13	14	15	16	17	18
Breakfast:										
Milk-cocoa	100	300	250	250	250	250	250	250	250	250
Roll	45	45	45	45	45	45	45	45	45	45
Raw eggs	2	2	3	3	3	3	3	1	3	3
Dinner:										
Soup	50	80	100	100	100	100	100	100	100	100
Beef	—	—	—	—	—	—	—	280	—	—
Veal	50	—	—	—	280	300	—	—	—	—
Fowl	—	½ fowl	1 pigeon	200	—	—	½ fowl	—	½ fowl	¼ fowl
Vegetables	—	3 potatoes	180	3 potatoes	230	400	—	150	150	—
Salad	—	—	—	80	—	—	—	—	3 potatoes	—
Pastry	—	—	—	—	—	—	250	200	—	300
Extras	—	—	—	—	—	—	Pâté	—	—	Rice broth, 350
Bread	—	—	—	—	—	—	—	1	1	1
Raw eggs	2	2	2	2	2	2	2	2	2	2
Supper:										
Meat	80	½ fowl	1 pigeon	180	230	250	½ fowl	230	½ fowl	¼ fowl
Extras	—	—	—	—	—	Cheese, 10	Macaroni 200	—	—	—
Bread	50	50	50	50	50	50	50	50	50	50
Raw eggs	2	3	3	4	5	4	2	3	5	5
Total raw eggs	6	7	8	9	10	9	7	6	10	10

The fluids consumed were of the same kind as on the preceding days, the quantity being :

On July 9, 1,200 c.cm.
On July 10, 1,100 c.cm.
And from July 10 to 18, 1,250 c.cm. daily.

TABLE OF AMOUNT OF ALBUMEN IN THE URINE.

(Reaction strongly acid throughout.)

Date	Number of raw eggs	Albumen contents in grms.	Urine in c.cm.	Sp. gr.	Percentage of albumen	Total quantity of albumen in grms.
July 9	6	38·4	740	1030	0·249	2·175
„ 10	7	44·8	870	1028	0·302	2 627
„ 11	8	51·2	810	1029	0·287	2·324
„ 12	9	57·6	930	1028	0·309	2·873
„ 13	10	64·0	1,270	1023	0·157	1·834
„ 14	9	57·6	1,200	1027	0·155	1·760
„ 15	7	44·8	1,130	1026	0·143	1·616
„ 16	6	38·4	1,250	1026	0·134	1·675
„ 17	10	64·0	1,130	1026	0·137	1·548
„ 18	10	64·0	1,150	1024	0·135	1·552

3. *After Discontinuing the Use of Eggs.*

The diet of the patient being much the same as before, it will not be necessary to specify it.

The fluids were the same in character, the quantity being 1,250 c.cm. daily.

AMOUNT OF ALBUMEN IN THE URINE.

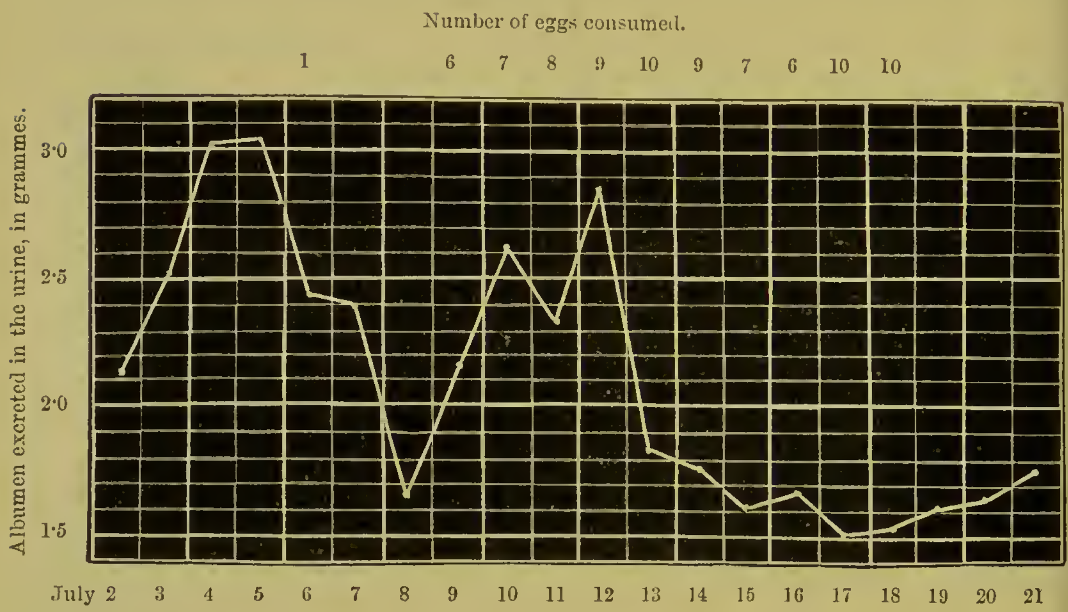
Date	Urine in c.cm.	Sp. gr.	Percentage of albumen	Total quantity of albumen in grms.
July 19	1,120	1025	0·144	1·612
„ 20	1,450	1024	0·114	1 653
„ 21	1,490	1024	0·120	1·788

In these experiments we observe the unexpected fact that egg-albumen, although taken in large quantities, causes no increase of albumen in the urine, *even in patients already suffering from albuminuria*; *i.e.* it is not excreted as such by the kidneys, but undergoes the usual destruction according to the laws regulating the tissue-changes of the body.

The course of the albuminuria throughout the whole series of experiments can be best followed by a graphic representation of the daily amount.

From July 2 to 7 the curve varies between 2·12 and 2·41; on July 5 it reaches its maximum with 3·04; and on July 8 it sinks to 1·65, in consequence of the slight diarrhœa of the patient. It then slowly rises, during a supply of six, seven, eight, and nine eggs daily, to 2·87, remaining then 0·17 grm. below the highest of the above figures; and on July 13, after

FIG. 2.



ten raw eggs had been taken, it falls to 1·83 (a diminution of 1·039 grm.), without again rising, or even maintaining the same level. On the following days it sinks slowly to 1·54 and 1·55, on which day ten eggs were taken. The lowest figures (1·54) were reached on July 17. After the 18th, when the eggs were discontinued, more albumen was excreted, and the curve rises, but after three days, July 21, it reaches only 1·78.

So far as the albuminuria behaved, we might fairly conclude from these experiments that a large supply of egg-albumen had a favourable influence upon it. The repeated diminution, at first so marked (1·039 grm.), of the albumen daily excreted, on the introduction of 64·0 grms. of egg-albumen, might well appear to justify such an assumption. Meanwhile, as in the preceding variations, so here we shall do better to regard these differences as due to varying intensity of the diseased processes going on in the kidneys, although *à priori* we must

indicate an increase of the albuminous constituents of the blood in hydræmia and albuminuria as favourable.

This much is certain, that a copious supply of egg-albumen to patients in whom there already exists a transudation of serum-albumen from the renal vessels, causes no increase of this, and that egg-albumen passes into the urine in small quantities as egg-albumen.

On viewing the collective result of these four series of experiments, we discover these facts—that *a great increase of albumen supplied to the blood causes no increased excretion of albumen by the kidneys*, and in particular that *egg-albumen gives rise to no irritation of the renal vessels and no albuminuria* (nor does it increase an existing albuminuria).

THE INFLUENCE OF NON-NITROGENOUS FOODS ON FAT-REDUCTION.

Having enquired into the influence of a non-nitrogenous diet upon the albumen-condition of the body, and having shown that in regard to fat-formation and fat-deposition the *quantity* alone determines the result, we shall now have to consider up to what amount a person suffering from obesity and circulatory derangements can take this kind of food, and still lose fat. Inasmuch as the non-nitrogenous foods are not quantitatively equivalent as regards fat-formation, and since, on the other hand, the degree of combustion of fat-forming substances within the body varies with the destructive capacity of its cells, and with the consumption of those substances in the functions of the body, especially in muscular activity, we must take account, in giving non-nitrogenous food and determining its quantity—

1. Of its quality, *i.e.* of its more or less easy destructibility and conversion into fat within the body; and

2. Of the greater or less destructive capacity of the cells of the body for fat-forming stuffs supplied to it.

Only when these two factors are considered can we determine the quantity which may be given without harm to the patient, *i.e.* without prejudicing the destruction of the fat proper of the body, which it is our object to encourage.

1. Of the non-nitrogenous foods, fat is the one which requires to be afforded in least quantity, as compared with other foods, for facilitating the functions depending on its destruction, viz. heat and force; and its excess is deposited in the body as fat. According to the latest investigations, conducted by Rubner in Voit's laboratory, on the substitution-values of fat, carbohydrates, and albumen, it resulted that those quantities of different foods may be regarded as *equivalent* or *isodynamic* which afford the same amount of heat on being oxidised to carbonic acid and water. In this respect the following are equivalent quantities:—

100 grms. fat		234 grms. cane sugar	
211 ,,	albumen	256 ,,	grape sugar
232 ,,	starch-stuffs		

the average of the carbohydrates being about 240.

From these figures it appears that one part of fat is isodynamic *with* 2·4 *parts of carbohydrates, on an average*; accordingly we must give more than twice the amount of the latter to produce the same effect as fat. We are therefore much less likely to overstep the limits prescribed by the patient's condition if we give carbohydrates than if we give fat, *i.e.* if their use is to be freely permitted, and if the influence of non-nitrogenous foods upon tissue-change is chiefly sought to be obtained by them. Besides this, a small excess of fat beyond what can be destroyed by the body is deposited as such, while large quantities of carbohydrates, even when they exceed the daily requirement, are still oxidised, and only when the excess is very great are small quantities converted into fat. According to Voit, deposition of fat begins when more than 118 grms. albumen and 259 grms. fat (=377 grms.) are taken. On the other hand, we can give without causing fat-deposition 118 grms. albumen and 600 grms. starch-stuffs (= 718 grms.) The proportion is most easily exceeded when, as in our mixed diet, fat and carbohydrates are given together, besides a moderate quantity of albumen. The limits will be about 118 grms. albumen, 100 grms. fat, and 368 grms. starch-stuffs (=586 grms.)

Accordingly, if we desire to bring about a destruction of the accumulated fat of the body by an abundant albumen-supply,

we shall best do this *by lessening the fat-supply, and by permitting only a definite quantity of carbohydrates.* Similar reasoning induced me, as early as 1875, to regulate the diet in this way in my attempts at fat-reduction, and the subsequent cases were dieted on the same principle.

2. But the patient's condition is also of great importance as regards the diet to be prescribed, as the destruction of each kind of food depends upon it. In treating obesity, therefore, we must divide our cases into two groups, viz. :—

a. Cases of fat-accumulation in which the respiratory and circulatory apparatus have undergone no special derangement, and the patient is capable of muscular effort and locomotion.

b. Cases in which, in consequence of advanced stasis and hydræmia (with deficiency of hæmoglobin), the amount of oxygen taken up from the lungs is extremely reduced, and the slightest muscular efforts are enough to disturb the respiration and provoke dyspnœa.

Locomotion is thus restricted to a minimum, for it cannot take place without increasing the respiratory trouble, and the patient avoids everything which even momentarily aggravates his distress. Finally, the destructive capacity of the cells of the body is lowered by the limited supply of oxygen to, and the accumulation of carbonic acid in, the blood, as well as by its poverty in albumen; hence the conditions favourable to the deposition of fat are increased.

From this investigation the necessity of a *varied supply* of non-nitrogenous food, according to the capacity of the organism for its destruction, is self-evident. While in cases belonging to the first group, where the cellular activity is fairly energetic, fat and carbohydrates may be given within wider limits, because, owing to the greater muscular work and locomotion, their destruction also is greater; in cases belonging to the second group the use of fat and carbohydrates must be restricted as far as possible, and *by simultaneous reduction of the fluids of the body the circulation must be again rendered free*, and the ready tendency to dyspnœa overcome. Then only will it be possible without injuring the patient to admit more variety in the diet by increasing the carbohydrates and especially the fat. But it is evident that in each of the above categories of cases

alterations will have to be introduced into the diet as the fat-reduction proceeds, because by-and-by the patients become rich in albumen and poor in fat, and the 'albumen-condition' of the body depends really on the 'fat-condition' and the non-nitrogenous elements of the food. We possess an approximate measure of the amount of fat and of carbohydrates to be supplied to patients of both categories, in the amount of nitrogenous and non-nitrogenous foods required to preserve at the same level the bodily condition of various persons under the different conditions of more or less strenuous muscular work and rest respectively.

A. For men in constant muscular activity the following are the figures:—

FOOD REQUIRED IN CONSTANT WORK.

No.	—	Albumen	Fat	Carbohydrates	Authority
1	Strong labourer	137	173	352	Pettenkofer and Voit[1]
2	Servant man	133	95	422	J. Forster[2]
3	Joiner	131	68	494	,,
4	Young physician	127	89	262	,,
5	,, ,,	134	102	292	,,
6	Strong old man	116	68	345	,,
7	Soldier under drill	135	80	500	Various authors, Voit[3]
8	,, in war	145	100	500	—
9	Man at easy work	120	40	530	E. Smith and Playfair[4]
10	,, at moderate work	153	68	508	,,
11	,, at hard work	160	66	580	,,
12	,, at strenuous work	184	71	570	,,
13	Italian brickmaker	167	117	675	H. Ranke[5]
14	Woodman in Reichenhall	112	309	691	Liebig[6]
15	,, in Oberaudorf	135	208	876	,,
16	Peasant in Laufzorn	134	108	788	H. Ranke[5]
17	Miner	133	113	634	E. Steinheil[7]
18	Prisoner at hard labour	104	38	521	A. Schuster[8]

[1] Pettenkofer and Voit, *Zeitschr. f. Biologie*, ii. p. 488, 1866.

[2] J. Forster, *ibid.* ix. p. 381, 1873; and in Voit's *Untersuch. der Kost*, &c., 1877.

[3] See Voit's *Handbuch der Physiol.*, vol. vi. p. 526, 1881.

[4] Playfair, *Edinburgh New Philosoph. Journ.*, 1854; *On the Food of Man in Relation to his Useful Work*, Lond. and Edinb., April 1865; *Medical Times and Gazette*, i. p. 460, 1865; ii. p. 325, 1866.

[5] H. Ranke, *Zeitschr. f. Biologie*, xiii. p. 130, 1877.

[6] Liebig, *Sitzungsber. d. bayr. Acad.*, ii. p. 463, 1869; *Reden u. Abhandlungen*, p. 121; *Chem. Briefe*, popular edit., ii. p. 521.

[7] E. Steinheil, *Zeitschr. f. Biologie*, xiii. p. 415, 1877.

[8] J. Schuster in Voit's *Untersuchungen der Kost*, p. 142, 1877.

B. For persons who work but little or rest altogether, compulsorily or not, we obtain the following values:—

FOOD REQUIRED DURING REST.

No.	—	Albumen	Fat	Carbohydrates	Authority
1	Minimum required for health .	66	24	330	Playfair
2	Maximum ,, ,, .	119	51	530	,,
3	Workman during rest . .	137	72	352	Pettenkofer and Voit
4	Poor woman	76	23	334	Forster
5	Woman in easy circumstances .	80	49	226	,,
6	Prisoner, not at work . .	87	22	305	Schuster
7	Poor workman, out of condition	86	13	610	Hildesheim [1]
8	Poor sempstress (London) .	54	29	292	Playfair
9	Trappist monk	68	11	469	Voit [2]

When the patient can perform the work demanded of him—the walks, ascents, and mountain-expeditions—we may afford him on any arduous day up to 50 grms. of fat and 200 grms. of carbohydrates as a maximum, while the minimum of albumen must be 150 grms. There is no danger to be feared of fat-formation from albumen, because 211 grms. of albumen are required to develop as much heat and force as are given out by 100 grms. of fat, and, according to Voit, fat-deposition only begins with the use of over 664 grms. of albumen (=3,027 grms. of flesh-meat).

But if the patient is already under the influence of severe circulatory derangements, as detailed earlier, we must scarcely exceed 25 to 30 grms. of fat and 100 grms. of carbohydrates. And since these patients are very poor in albumen, the supply of this must not fall below the 150 grms. established for patients of the first category, but should considerably exceed it.

SPECIAL DIET IN OBESITY AND CIRCULATORY DERANGEMENTS.

In the following tables I have attempted an arrangement of foods and drinks according to their character and relative amounts of albumen, fat, and carbohydrates. Regard has been

[1] Hildesheim, *Die Normaldiät*, p. 67, 1856.
[2] Voit, *Untersuchungen der Kost*, p. 17, 1877.

TABLE I.

Fluids	Quantity in grms.	Water	Albumen	Fat	Carbo-hydrates	Analysis by
Morning:						
Coffee . .	120·0	113·6	0·21	0·62	1·7	v. Voit[1]
Milk . . .	30·0	26·2	1·29	0·96	1·2	König[2]
Sugar . .	5·0	0·1	0·02	—	4·8	,,
Afternoon:						
Coffee . .	100·0	94·7	0·18	0·52	1·4	v. Voit
Milk . . .	25·0	21·8	1·05	0·8	1·0	König
Sugar . .	5·0	0·1	0·02	—	4·8	,,
Water . .	50·0	50·0	—	—	—	
	(to100)	(to100)	—	—	—	
Evening:						
Wine [Pfälzer] .	187·5	161·2	—	—	5·6	König
Water . .	50·0	50·0	—	—	—	
Total . .	572·5	517·7	2 77	2·9	20·5	

Total quantities taken within 24 hours, in grammes:

Water . .	938·3	Albumen .	156·7
Fat . .	22·1	Carbohydrates	71·5

Solids	Quantity in grms.	Water	Albumen	Fat	Carbo-hydrates	Analysis by
Morning:						
Fine wheat bread	35·0	12·4	2·4	0·2	19·6	König
Midday:						
Soup . . .	0	—	—	—	—	—
(Fat boiled beef .	200·0	113·6	68·3	15·0	0·8)	König(C.Krauch)
Thin roast beef .	200·0	116·0	76·4	3·4	—	v. Voit
Salad [green] .	25·0	23·5	0·3	1·0	0·5	König (in part)
(Green vegetables .	50·0	35·5	0·8	0 2	4·2)	v. Voit
(Puddings, &c. .	100·0	45·0	8·7	15·0	28·9)	Average of seven kinds after Renk
Bread [roll] .	25·0	7·0	2·4	0·2	15·0	Renk
Fruit . . .	100·0	85·0	3·0	—	15·0	v. Voit
Evening:						
2 eggs [soft boiled]	90·0	66·2	11·2	10·8	0·4	König
Roast meat . .	150·0	87·0	57·3	2·6	—	v. Voit
Salad [green] .	25·0	23·5	0·3	1·0	0·5	König (in part)
(Cheese . . .	10·0	3·6	2·4	3·0	0·4)	König
(Bread . . .	25·0	7·0	2·4	0·2	15·0)	Renk
(Fruit . . .	100·0	85·0	3·0	—	15·0)	v. Voit
Total . .	650 0	420·6	154·0	19·2	51·0	

[1] Voit, *Untersuchung der Kost in einigen öffentlichen Anstalten.* Compiled in combination with Dr. J. Forster, Dr. Fr. Renk, and Dr. Ad. Schuster. Munich, 1877.

[2] J. König, *Chemische Zusammensetzung der menschlichen Nahrungs- und Genussmittel*, 2nd edit., Berlin, 1882; and *Die menschlichen Nahrungs- und Genussmittel u.s.w.*, 2nd edit., Berlin, 1883.

TABLE II.

Fluids	Quantity in grms.	Water	Albumen	Fat	Carbo-hydrates	Analysis by
Morning:						
Coffee . .	120·0	113·6	0·21	0·62	1·7	v. Voit
Milk . . .	30·0	26·2	1 29	0 96	1·2	König
Sugar . .	5·0	0·1	0·02	—	4·8	"
Midday:						
Wine [Pfälzer] .	187·5	161·2	—	—	5·6	König
(Water . .	100·0	100·0	—	—	—)	
Afternoon:						
Coffee . .	100·0	94·7	0·18	0·52	1·4	v. Voit
Milk . . .	20·0	17·4	0·86	0·64	0·7	König
Sugar . .	5·0	0·1	0·02	—	4·8	"
Water . .	100·0	100·0	—	—	—	
Evening:						
Wine [Pfälzer] .	250·0	216·3	—	—	7·5	König
(Water . .	200·0	200·0	—	—	—)	
Total . .	817·5	729·6	2·8	2·7	27·7	

Total quantities taken within 24 hours, in grammes:

Water	1299·2
Albumen . . .	169·9
Fat	43·5
Carbohydrates . .	114·0

Solids	Quantity in grms.	Water	Albumen	Fat	Carbo-hydrates	Analysis by
Morning:						
Fine wheat bread	35·0	12·4	2 4	0·2	19·6	König
	(up to 70·0	24·9	4·9	0·4	39·2)	"
(Butter . . .	12·0	1·7	0·08	9·9	0·06)	"
Midday:						
Soup . . .	0	—	—	—	—	
	(to 100·0	91·6	1·1	1·5	5·7)	Renk
(Fish . . .	100·0	74·7	22·1	0·6	0·7)	König
(Vinegar . .	25·0	23·5	—	—	0·1)	"
Beef, roast . .	200·0	116·0	76·4	3·4	—	v. Voit
Beef, fat, boiled .	200·0	113·6	68·3	15·0	0·8	König
Salad [green] .	50·0	47·1	0·7	1·0	1·1	"
(Vegetables [green] .	50·0	35·5	0·8	0·2	4·2)	v. Voit
Pastry, &c. . .	100 0	45·0	8·7	15·0	28·9	Mean of seven anal. by Renk
(Bread [roll] . .	25·0	7·0	2·4	0·2	15·0)	Renk
Fruit . . .	100·0	85·0	0·3	—	15·0	v. Voit
Evening:						
Caviare . .	12·0	6·4	3·0	1·5	—	König
(Sardines . .	16·0	9·4	3·6	2·4	0 14)	"
(Salmon [smoked] .	18·0	9·2	4·3	2·1	0·07)	"
2 eggs . . .	90·0	66·2	11·2	10·8	0·48	"
Grouse, fowl, or beefsteak . .	150 0	87·5	57·3	2·7	—	v. Voit
Cheese . . .	15·0	5·4	3·6	4·5	0·6	König
Bread . . .	25·0	7·0	2·4	0·2	15·0	Renk
(Fruit . . .	100·0	85·0	3·0	—	15·0)	v. Voit
Total . .	877·0	569·6	167·1	40·8	86·3	

had also to the quantity of the fluid-supply, thus anticipating the amount resulting from the succeeding experiments.

Of the foods and drinks mentioned in the foregoing table, an increase of one or other constituent may be permitted according to the progress of the fat-reduction; or, again, the general composition remaining the same, variations may be made in it. Thus, we may begin with an increase of bread, or cheese, or fruit, or of all these at once, raising

the water	up to	1033·0	grms.
the albumen	,,	163·8	,,
the fat	,,	45·7	,,
and the carbohydrates	,,	101·9	,,

Or instead of this, 100 grms. of flour-foods may be allowed at times (= an increase of water 45 grms., albumen 8·7 grms., fat 15·0 grms., and carbohydrates 28·9 grms.)

The diet of Table II. may also be varied like that of Table I.

It is evident that the quantities here given must not be looked upon as absolute and fixed for every patient, but they indicate the limits between which the diet may arrange itself according to the peculiarities of the particular case, the amount of fat-accumulation, the severity of the circulatory derangements, the capacity for work, and the advance of the fat-reduction. No difficulties attend the composition of the separate meals, regard being had to the principles laid down.

As the *minimum* quantities of water, albumen, fat, and carbohydrates in the solids and fluids of the diet, we have, in grammes—

	Water	Albumen	Fat	Carbohydrates
	938·3	156·7	22·1	71·5
and as the *maximum*	1299·2	169·9	43·5	114·0

These latter quantities can only be given when, owing to strenuous muscular activity, as in mountain-climbing, there is increased destruction of non-nitrogenous material within the body and increased need of food.

In cases of adiposity without circulatory disorders the supply will be far less restricted.

According to Voit a reduction of fat will occur under the use of the following supply:—

	Albumen	Fat	Carbohydrates	Fat-equivalent of latter
Voit . . .	118	40	150	161
Harvey (Banting)	172	8	81	124
Ebstein .	102	85	47	154
Oertel, minimum	156	22	71	127
(maximum	170	43	114	173)

The quantities of albumen, fat, and carbohydrates given by myself thus differ considerably from those of Harvey-Banting, as well as from Ebstein's, the minimum values representing a little more fat, less carbohydrates, and less albumen than the Harvey-Banting, but the maximum values being all three larger, especially the non-nitrogenous. The reasons for this have been already thoroughly entered into. Ebstein allows far too little albumen, especially for patients suffering from albuminuria and hydræmia—in fact, it is hardly the amount required for the maintenance of normal health. With such a quantity as this the raising of the greatly lowered albuminous condition and the formation of organic albumen are impossible.

The *fluid supply, which is of the greatest importance* in obesity, fatty heart, and allied disorders, as well as for a speedy and safe fat-reduction, is disregarded by both of them.

ON THE INFLUENCE OF THE REMOVAL OF WATER FROM THE BODY UPON FAT-REDUCTION.

There lie before me two observations on obesity and fatty heart, in both of which there was marked reduction of the water of the body by simply restricting the supply, without any alteration in the solids of the diet, and where also no severe muscular exertions were undergone, during the winter season in which the cases were treated. In neither case therefore was the fat-combustion increased by work, nor the excretion of water by any mechanical means. The reduction of the fluids of the body was entirely due to the lessened supply of water, which was limited to the amount necessary for tissue-change.

[1] The fat-equivalent for the carbohydrates corresponding to 232 grms. of starch-stuffs. By an error in Voit's work, *Ueber die Ursachen der Fettablagerung*, the fat-equivalents of Banting, Ebstein, and others are there incorrectly given, and the above figures must be substituted.

But the fat-accumulations of the body, especially those of the breast and abdomen, underwent a most extraordinary and striking diminution. Whilst the tela adiposa on the above regions had previously formed a layer several centimetres thick, after from two to two and a half months hardly any fat could be noticed, and the skin was connected with the subjacent muscles over the thorax and abdomen merely by a thin connective tissue, with scarcely any fat in it.

In these cases the fat-reduction appears to stand in a definite, not altogether explained, relation to the reduction of the supply of fluids. Disregarding the differences of opinion on the histogenesis of fat, we find in the above investigations repeated evidence of the intimate connection which exists between the adipose and vascular tissues. The deposit of fat-cells, whether formed from cell-elements of a special tissue-formation (Toldt) or from ordinary connective-tissue cells, invariably occurs in or upon the adventitia of previously formed vessels (both arterial and venous), also upon the capillaries connected with them, but never apart from vessels. Fat, for the most part, does not exist as such in the blood, but circulates chiefly as a lipogenous material, which only later on, when it has passed through the vascular wall, is either converted into fat in certain appointed cells (Toldt), or else undergoes this change within the vascular wall and is then taken up by the tissues as a normal constituent (Flemming). Wherever partial vascular dilatations occur, the lipogenous material transudes more freely, and is at once absorbed by the connective-tissue cells of the adventitia. In these, at first usually small, vascular tracts or areas are formed separate fat-lobules, which then coalesce to form an extensive fatty tissue; wherever these agglomerations of fat occur, the adventitia is found to be loose in texture and filled with fat-globules. In such places, moreover, Flemming has observed numerous migratory cells in the adventitia, and from this limited immigration of blood cells, he concludes that there is a considerable *local retardation of the circulation*, which can only be explained by the occurrence of a local vascular dilatation.

In our cases, in which there is very great circulatory derangement with extensive venous stasis, all the conditions for

retardation are present, and an important co-operative factor in fat-formation is thus afforded.

If now we seek an explanation of the rapid fat-reduction in the above two cases, in which the previous diet remained unaltered, and in which—supposing even, against their positive assurance to the contrary, that the patients took less solid food than before—this certainly suffered no reduction corresponding to their emaciation, we find that the only alteration from the previous mode of life was the extreme reduction of the fluids imbibed. Inasmuch as by this reduction and the removal of venous stasis the circulation was brought nearer to the normal and *quickened*, it followed in the first place that the favourable dispositions for the development of fat, the stasis and dilatation in certain vascular areas, were diminished; and, secondly, that the continuous reduction of the blood caused partial anæmia and obliteration of larger or smaller vascular areas.[1]

The most immediate result of the reduction of the water of the body consequent on the diminution of the water-supply is that the vessels generally no longer hold the same volume of blood as before, and the lessened quantity moreover is not distributed as it would be in a simple canal-system. The vessels are able by contraction and dilatation to adapt themselves to the quantity of blood in them at any particular time, and thus a more constant balance is obtained, though only up to a certain degree. The great vascular trunks and the vessels carrying blood to and from the glandular organs and the muscular apparatus will certainly adapt their calibres to the reduced blood-volume; but, owing to vasomotor influences, not much less of the richer blood than before, or about the same amount, will be conveyed to those organs according to their tissue-changes and functional activity. To facilitate this supply with an absolutely smaller quantity of blood in the body, it will be reduced in and drained away from places where the tissue-changes are less energetic, and which are less favourably innervated.

Such vessels are above all those in the fatty tissue—vessels branching in the panniculus adiposus. If this vascular condition

[1] Compare Flemming and Toldt, *Rückbildung der Gefässe des Fettgewebes bei starker Abmagerung*, Toldt, 'Gewebelehre,' p. 160, Stuttgart, 1884.

persist and is not merely temporary, the immediate consequences will be anæmia and vascular obliteration over larger or smaller areæ, and these changes, again, will be accompanied by nutritive disturbances, especially in fatty tissue, and by disintegration and absorption of their elements. Such a process must be regarded as physiological no longer, but pathological.

But the last change of the reabsorbed fat will be its final combustion. Since a larger quantity of blood is conveyed to the tissues after the venous stasis is compensated, on the one hand the cellular activity will be increased, or rather will become normal again ; on the other, muscular exertion will become possible after the cessation of dyspnœa, and the formation of an excess of non-nitrogenous matter in the blood will be prevented. But these factors directly govern the fat-combustion, and the latter will now be more thoroughly carried out than it could have been during the preceding arterial anæmia and hydræmia, just as we observe increase of oxidation and heat-production after the disappearance of chlorosis. Moreover we can still further increase fat-destruction by increasing the consumption of the non-nitrogenous constituents of the body by persistent muscular exercise, while at the same time lessening their supply.

Finally, while on this subject, we must not forget that where, by reducing the fluid-supply, the deposited fat has been made to disappear wholly or in part, the dangers mentioned in describing the purely dietetic methods of fat-reduction will still exist; *an atrophied, inefficient heart muscle* will still remain ; though any sudden catastrophe due to this is no longer to be feared, owing to the diminution of the quantity of blood in the body and its easier circulation. In such cases, the most important step, next to reducing the fluids of the body, is to strengthen the heart-muscle, with restoration of its functional capacity or of any previous compensations, and this also may be successfully carried out if not undertaken too late.

C. *ON THE MECHANICAL CORRECTION OF CIRCULATORY DISORDERS.*

As already mentioned in our first statement of the problem before us, it is not enough to combat the morbid processes by reduction of the body-fluids and alteration of the diet also, but we must endeavour to correct the hydrostatic derangements themselves, and to bring about vascular alterations which will permit us to expect a permanent result.

As far as the *first* point is concerned, our main object will be to re-establish the balance between the arterial and venous apparatus, *i.e.* to equalise as far as possible their contained volumes of blood respectively, so that

a. The blood dammed up in the veins may be driven onwards and a quicker flow be caused;

b. The circulation may be rendered easier in the pulmonary capillaries, and the arteries generally may hold more blood.

Secondly, when the circulatory apparatus has undergone an irreparable lesion, we must restore the failing compensation, instituted by Nature herself, but no longer sufficient; and since this is situated in the heart itself, we must strengthen the heart-muscle and produce a compensatory hypertrophy. We must also influence, though indirectly, the vascular walls, especially when their filtering powers have suffered and dropsical transudations have occurred.

Whatever method of mechanically correcting the circulation be adopted, it must evidently be such as will operate at once upon the circulation. We cannot hasten the flow of blood from the veins, unless at the same time we increase the amount in the arteries, and we shall effect neither unless the heart is in a position to receive and drive on the blood reaching it. The means of effecting this must be sought only in the physio-

logical processes of the circulation and the conditions under which they are carried on; any result by other means, as by the use of drugs, is out of the question. The *unloading of the whole circulation* (accompanied or easily followed by a mechanical influence, viz. muscular exertion) remains as the indispensable condition of a favourable alteration of the distribution and flow of the blood.

For the establishment of our method it will now be necessary, as far as appertaining to our problem, to examine carefully the forces which cause the movement of the blood, both arterial and venous, and to consider the influences by which we may compensate the hydrostatic derangements. The first object of our investigations will be the stagnation in the venous apparatus, and the flow of blood therein.

I. INFLUENCES ACTING ON THE VENOUS FLOW.

In order to hasten the flow of the stagnant venous blood, we must act upon it from two aspects, viz. *peripherally*, by a force influencing the flow from the capillaries into the veins in their widest extension, and rapidly impelling towards the centre the blood accumulated in the dilated vessels, and also *centrally*, by a force assisting this movement and proportionately furthering the venous current towards the heart.

a. Peripherally.

The normal driving power of the heart leaves little over for the onward movement of the blood beyond the arteries, but if this power be weakened by cardiac disease there is no surplus left. The movement of the blood in the veins will then depend exclusively upon a number of mechanical influences, which normally (in addition to the cardiac energy) acts towards the centre.

The *weight of the blood* acts in the easily stretched veins (in contrast with the arteries) in the first place on its distribution, and thereby necessarily on its movement. The emptying of the veins which pass downward to the heart is directly aided by gravity, which, on the other hand, opposes the flow of blood

in those veins which take an ascending course. Under proper conditions the patient may adopt the horizontal position and thus the return of the blood from the periphery may be facilitated in the ascending veins. The disappearance of œdema from the lower limbs by the adoption of the recumbent position is due to the lowered pressure in the veins.

Alteration of position of the limbs at the joints aids the circulation in the veins, and forms a mechanical factor of especial value in our problem, as it acts more strongly than gravity. According to Braune's experiments,[1] if the thigh be sharply rotated outwards, and at the same extended to the utmost, the femoral vein lying in the fossa ovalis beneath Poupart's ligament will be seen to collapse; and, *vice versâ*, it refills on restoring the limb to its previous position, becoming quite distended if the thigh be flexed on the abdomen. By a manometer inserted in the vein, Braune found that the former position caused a negative pressure of $\frac{1}{2}$ cm. to 1 cm. of water, which was changed to a positive pressure by the latter position. In lesser degree the above movements take place with every step we take, but most effectively in ascending stairs or elevations, owing to the lifting motion with flexion of the thigh, succeeded by the backward motion, with external rotation and extension. Here the whole disposition of the surrounding bones, muscles, fasciæ, and valves of the veins is such as to form an alternately sucking and forcing apparatus, and hence to pass on energetically towards the heart the blood stagnated in the lower limbs.

Herzog proved the existence of a similar aspirating mechanism for the great venous trunks of the neck and upper extremity.

Any work of the arms which moves the shoulders causes movements of the clavicles which alternately compress together and separate the venous walls. This is mainly the case on strenuous exertion, but it occurs also in simple walking, owing to the pendulum-like motion of the arms. All movements of the head and shoulders act in a similar way (especially in forced respiration, when the thorax and clavicles are raised and all the cervical muscles are in action), by causing alterations of

[1] Braune, *Ber. d. sächs. Ges. d. Wiss.*, xxii. p. 261, 1870.

size in the various trunks and favouring the flow of blood to the right heart.

In another series of experiments Braune has shown that in *certain positions of the body* the veins are so stretched that their walls offer a resistance to external pressure, and an increase in size takes places, which causes *aspiration*. The chief veins of the body are placed in this condition of extreme tension by extension at all the joints, especially of the lower extremity, and it is well seen in the arm when held horizontally with the fist tightly clenched. Contrariwise, the veins of the lower limbs are most relaxed in the sitting, or rather crouching, position, when the joints are well flexed.

Accordingly we find in the above mechanism, by varying the disposition of the limb at each joint, as Braune has shown, a means of hastening the venous flow, and of obtaining the most favourable compensation in circulatory derangement. All the movements in question, especially those of the lower limbs and glutei, are continuously performed for hours together in mountain-climbing, and with the greatest energy. The arm movements also (less in simple pendulous action in walking than by the use of the alpenstock in scrambling uphill), together with the action of the great pectoral muscles owing to the much increased respiration, will cause great activity of the aspirating mechanism of the upper thoracic aperture described by Herzog, and will increase the flow of blood from the veins of the upper extremities, head, and neck.

Moreover *contraction of the voluntary muscles* assists the centripetal flow in the veins. When the muscles contract any veins embedded amongst them are easily compressed, and thus the blood is impelled centripetally, the valves preventing any flow in the opposite direction. Again, the blood which has accumulated at the peripheral end of the portion of vein compressed will flow onwards into this portion when the pressure is removed on relaxation of the muscles.

If the muscular contractions be repeated, as occurs in locomotion, &c., the circulation will be greatly assisted (the valves preventing any backward flow), and the more so as the contractions become more general and energetic. From all this it is evident that the movement of the blood caused by

muscular action is increased far more by ascending elevations and hill-climbing than by simple locomotion on level ground, which is also usually of shorter duration.

b. Centrally.

Not only are there forces acting peripherally which propel the blood from the capillaries onwards in the veins, but there is also a *central aspiration* by the heart and thorax, which must quicken the flow of blood from the great venous trunks into these.

1. *Cardiac Aspiration.*

Purkinje [1] and Nega [2] established the fact that the blood is drawn into the heart at the moment of systole. Weyrich [3] showed by experiments on dogs that there is an aspiration independent of respiration, and synchronous with the cardiac pulsations. This he called the *auricular aspiration.* A number of other observations also belong here. Voit [4] observed in experiments which he and Lossen conducted together, and in which respiration took place through a Müllerian valve, that there occurred regular variations synchronous with the heart-beats whenever the respiration was at rest, whether during in- or expiration; the water rose in the expiratory and sank in the inspiratory valve with each ventricular systole, while the reverse occurred during diastole. Voit explains this by supposing that the volume of the heart is lessened in systole, and that it resumes its previous size in diastole, and he draws attention to Bamberger's observations on this point.[5] In these it was shown, through the exposed pleura of the rabbit, that the ventricles drew towards them the lungs at each systole. Marey [6] and Mosso [7] have indicated this movement of the adjacent

[1] Purkinje, *Jahresber. d. schles. Ges. f. vaterl. Cultur*, p. 157. Breslau, 1843.

[2] Nega, *Casper's Wochenschr.*, 1851, pp. 661, 673.

[3] Weyrich, *De Cordis Aspiratione Experimenta.* Dorpati, 1853.

[4] Voit, *Zeitschr. f. Biologie*, i. p. 390, 1865.

[5] Bamberger, *Virch. Archiv f. pathol. Anat.*, ix. p. 345, 1856.

[6] Marey, *Physiol. Méd. de la Circulation*, p. 122. Paris, 1863.

[7] Mosso, *Archivio per le scienze mediche*, ii. p. 401, 1878; *Die Diagnostik des Pulses u.s.w.*, p. 42. Leipzig, 1879.

structures towards the heart during systole by the term 'negative pulse' of those parts, and the movement in the opposite direction (synchronous with the diastole) as the 'positive pulse.' Of great importance, according to Mosso, is the strength with which the heart empties itself. So great is this energy, that not only is a negative pulse of the air in the lungs observed, in spite of their elasticity, but even elevation of the diaphragm and sinking in of the thoracic wall, *i.e.* a negative pulse of the thorax and abdomen. Such a force must doubtless quicken the flow of blood from the great thoracic veins during the ventricular systole into the auricles, which without this aspiration would take a much longer time to fill. Finally, Mosso has shown the existence in healthy persons of a negative pulse in the jugular veins, almost synchronous with the positive carotid pulse.

The force with which aspiration ensues is a variable one, and depends upon the condition of the heart at the time as to strength and degree of excitability. If these are lowered by disease, such as fatty heart, fatty degeneration, or derangement of compensatory changes, aspiration is lowered considerably; on the other hand, increased strength and excitability of the heart increase *pari passu* the aspiration of blood into the auricles, and quicken its flow in the veins. Any influences, moreover, which act upon the heart in this direction, such as walking quickly or ascending elevations, increase the aspirating force of the heart, and hence influence the venous circulation generally.

2. *Thoracic Aspiration.*

A second central aspirating force is found in respiration, when, owing to the comparative rigidity of the thoracic wall and the elasticity of the lungs, there arises a negative pressure in the thorax, while the veins outside it are subjected to the atmospheric pressure plus the tension of the tissues through which they course. If by making the respirations deeper we increase the negative thoracic pressure, we increase to an equal degree the flow of blood into the right heart, and *vice versâ.* The more involuntary and automatic the respirations become (the more energetically, continuously, and equably they are

performed), the greater is their influence upon the circulation. The deep involuntary respirations evoked by the ascent of elevations is associated also with powerful cardiac contractions at every step, and thus the double influence of the thorax and heart is brought to bear upon the circulation.

II. INFLUENCES AFFECTING THE CIRCULATION IN THE LUNGS AND ARTERIES.

a. In the Lungs.

It may be presumed that, if the venous circulation be quickened, we must afford sufficient space to receive the increased quantity of blood reaching the heart, without over-accumulation. If the thorax be expanded and the capacity of the lungs proportionately increased, the alveolar capillaries will be enlarged in length and breadth, and the capacity of the pulmonary vessels will thus be increased. The lungs will then receive more blood during inspiration in proportion to their volume, and the increased quantity of blood reaching the right auricle from the veins outside the thoracic cavity during inspiration can be at once driven onward by the right ventricle into the lungs.

But the outflow from the pulmonary veins into the left auricle is also increased by respiration, especially forced respiration. The pressure in the pulmonary vessels is variably affected by the alterations of the intra-thoracic pressure. If the latter be strongly negative the pressure in the pulmonary artery is only slightly, but that in the pulmonary veins considerably, lowered. The difference between the arterial and venous pressures will thus be increased, and the pulmonary circulation will be quickened. There is, moreover, another factor which quickens the pulmonary circulation, viz. the aspirating force of the auricles during systole. As already explained, these aspirate the blood, on the one hand, from the great venous trunks into the right auricle, and, on the other, from the pulmonary veins into the left auricle, and thus proportionately quicken the pulmonary circulation.

Finally, the frequency of the cardiac pulsations *increases*

during inspiration and decreases during expiration (Einbrodt, Kuhn). But since the heart fills and empties oftener during inspiration, more blood is then driven into the lungs in the same unit of time, and the circulation in these is quickened. The alteration in the cardiac frequency itself during respiration is of nervous origin (Einbrodt, Hering,[1] Sommerbrodt[2]).

The influences which quicken the pulmonary circulation are hence partly the same as those which hasten the flow in the systemic veins, viz. increased *aspiration* by the lungs and heart, and increased *activity* of the latter. These, again, are evoked and sustained by increased muscular exertion, such as rapid walking and the ascents of elevations. The means by which we endeavour to bring about a quicker flow of the stagnant venous blood to the right heart, viz. walking and forced respiration, are the very same means which also preserve more room for its reception in the lungs, and which favour its flow thence into the left heart. We are thus afforded a means of mechanically influencing the pulmonary circulation in no slight degree.

b. In the Arteries.

We find on attempting to increase the flow of blood in the venous apparatus and lungs by muscular exercise, notably by ascents, that not only is the flow in those quickened, but more blood is sent into the arteries; the aortic system is fuller while the venous system is unloaded, and thus the previous hydrostatic derangement is mitigated.

Before discussing the forces at our command for increasing the arterial flow, we must examine whether our theoretical suppositions are correct, whether we are in a position to correct the blood-flow and to obtain greater arterial filling by increased work, *i.e.* by hill-climbing. It now becomes a question, how do the arteries behave under this influence, not only during the exertion but after it? Do they take up more blood? and is the altered blood-distribution evident for some time after the

[1] Hering, *Sitzungsbericht der Wiener Akad.*, lxiv. (2), p. 333, 1871.

[2] Sommerbrodt, *Ueber eine wichtige Einrichtung des menschlichen Organismus.* Tübingen, 1882.

exertion? These questions can only be answered experimentally, and we shall thus consider—

a. The blood pressure, and arterial fulness;

b. The behaviour of the arterial wall under these influences, not only directly before and after the experiment, but some hours afterwards, the patient having rested altogether or nearly so.

EXPERIMENTS ON BLOOD-PRESSURE, AND ARTERIAL FULNESS AND TENSION. TEMPERATURE-DETERMINATIONS.

In order to find what alterations in the vascular apparatus result from strenuous exertion and hill-climbing, and the consequent influence on the circulation, a series of determinations of the blood-pressure were made (by the use of the sphygmograph and thermometer), some during rest in the ordinary condition, some after a long walk, some after mountain ascents. In the last case the observations were made not only on reaching the summit but on returning home, and also some hours afterwards, as well as on the next day. The whole of the experiments were made by Dr. N—— during his two visits to Schliersee from the end of July to the middle of September 1882 and 1883.

1. In *estimating the blood-pressure*, the sphygmo-manometer of v. Basch was used (in its altered form, as most kindly sent me by its inventor). Inasmuch as this instrument gives no absolute values for the blood-pressure, the figures obtained are only approximate, but in the same individual these figures indicate the variations of blood-pressure with sufficient accuracy, under similar conditions. The apparatus has been frequently used, and its usefulness in comparative measurements shown by Zadek,[1] Christeller,[2] and Lehmann,[3] and I can confirm their opinion in all essential points. The instrument has gained very much in portability in its present form, in which, instead of a column of mercury, a metal manometer constructed by the capsule of an aneroid barometer serves for registering the

[1] J. Zadek, 'Die Messung des Blutdruckes am Menschen mittelst des Basch'schen Apparates,' *Zeitschr. f. klin. Med.*, vol. ii. part iii. 1881.

[2] P. Christeller, *Ueber Blutdruckmessungen am Menschen unter patholog. Verhältnissen*, ibid. vol. iii. part i. 1882.

[3] S. Lehmann, *Blutdruck nach Bädern*, ibid. vol. vi. part iii. 1883.

pressure. Its portability is best shown by the fact that it was carried to the summits of the mountains and then used at once, without ever getting out of order.

On using the instrument the connection between the radial and ulnar arteries which existed in this case was interrupted by winding a caoutchouc tube two or three times round the wrist. The movement of the pulse was shown by a long needle bearing a little paper flag, and stuck into a cork plate fastened over the radial artery by an elastic band. Each determination was made in a twofold manner (von Basch): first, the plate was pressed down upon the artery till the movements of the needle ceased, and the deflection of the manometer needle was then noted; secondly, this or a somewhat higher pressure was used at once upon the artery, and slowly lessened till the needle again showed pulsations. The mean of both determinations was then taken. It is necessary, for the attainment of uniform results, to accurately mark the place for compression of the artery, so that the resistance may be the same each time the plate is applied.

2. In order to obtain information as to the *increase of volume* and the *degree of fulness* of the arteries, suitable observations were made on the temporal artery, which was especially adapted for this. In the subject of our experiments the left temporal artery ran very superficially towards the mid-frontal region, though neither its trunk in the temporal nor its branches in the frontal region were ordinarily discernible. But when the patient exerted himself severely and the heart's action was much increased, the artery became prominent above the level of the temporal region and could be easily followed to its finer branches.

Close to the hair of the temporal region four centimetres from the outer palpebral aperture the vessel projected about four millimetres above the level, and after giving off two small twigs directed vertically upwards, coursed towards the frontal region. At the angle made by the facial and temporal surfaces of the frontal bone, it projected about two millimetres above the surface, and three millimetres in width. After this it became rapidly smaller, as its branches were given off.

The portion of artery at the above angle was the part selected in the following experiments on increase of volume and arterial filling, the breadth of the artery being measured by a fine pair

of callipers. But the rest of the vessel and the separate branches were also carefully noticed, and their greater or less prominence and visible extent and more or less sharply defined windings gave additional indications of the varying quantities of blood conveyed by them.

3. For indicating the *pulse-curve* and determining the *arterial tension*, Sommerbrodt's loaded sphygmograph was chiefly used, but on the summits of mountains Marey's sphygmograph was found preferable on account of its portability and its easier indications (with ink). Sommerbrodt's apparatus has this advantage, that a definite pressure is employed in all investigations, and when the pulse-curves are larger a higher pressure is not required proportional to the greater tension. The loading was established once and for all at 200 grammes. Moreover the curve-forms which the very movable needle of this instrument makes upon a sooty surface are more exact, and their peculiarities are much better expressed than with Marey's instrument, the arcuate lines from which can often be explained only by a second observation with Sommerbrodt's. It need hardly be said that in all essential points the curves obtained from both instruments perfectly agree.

4. Finally, the *temperature* was ascertained by two maximal thermometers, applied the one in the axilla, the other under the tongue, and then compared together. To every determination, whether during rest or work, at least a quarter of an hour was given, so as to ensure perfect accuracy.

The rapid cooling of the body, owing to the low external temperature, was often very unfavourable to the temperature observations in the axilla, especially during cold winds or rains, which soaked the clothes and not only quickly cooled the skin, but prevented the warming of the thermometer in this part. In the mouth, the thermometer should be kept under the tongue as far as possible from the teeth. When simply laid upon the tongue there is a danger of cooling it by the rapid respirations in hill-climbing, unless the lips are perfectly closed. The low figures (down to 31·8° C.) which Lortet [1] obtained during his ascents of Mont Blanc may perhaps be thus explained.

The results of the different investigations were as follows:—

[1] See M. L. Lortet, *Deux Ascensions au Mont-Blanc*. Paris, 1869.

A. Resting and Walking on Level Ground.

Experiment I.—Rest.

The determinations were made at various times of the day, the patient remaining at rest, or very nearly so.

Blood-Pressure.—a. Twelve estimations at a time were made at various times of the day, the averages obtained being

124, 126, 128, 125, and 130 mm. of mercury.

From these the average of 126 mm. Hg for the day was taken. The lowest value was 122, the highest 135 mm. Hg, but the latter was exceptionally high.

b. The figures obtained at the different times of the day were as follows :

September 9	8 A.M.	10 A.M.	Noon	2 P.M. (after eating)	4 P.M.	7 P.M.	9 P.M. (after eating)
Blood-pressure in mm. Hg	123 125	124 127	126 128	127 129	128 130	127 123	124 125
	125 125	124 126	127 126	129 128	129 129	125 125	126 128
	124 125	127 128	130 129	129 130	127 129	125 122	129 129
	123 126	125 127	30 130	130 128	129 130	124 123	128 127
	126 123	129 130	130 129	129 128	125 129	125 126	127 128
	123 122	127 128	130 129	131 128	128 130	124 122	127 127
Average .	124	125	128	129	128	124	127
Pulse .	80	80	88	92	92	84	92

Arterial Fulness.—The temporal artery cannot be distinguished by the eye in either the temporal or frontal region ; it is barely perceptible to the finger at the lateral angle of the frontal bone, but the branches cannot be made out. On pressing strongly the pulsations are distinctly felt.

Arterial Tension.—The pulse-curve, which served as a basis in later investigations, had the following form, as taken with Sommerbrodt's sphygmograph at midday, after an hour's rest (fig. 3).

The line of ascent is almost vertical, reaching a height of seven mm., and it forms a very acute angle with the descending line. The first wave of elasticity (due to closure of the aortic valves[1]) is discernible with varying distinctness, two to two and a half mm. below the summit; and lower down, five mm. below the summit, is the recoil wave, or first wave of closure according to Moens.[2] Next to the recoil wave come two waves of elasticity, seldom more, and then the next ascent begins. The length of each abscissa is about

[1] L. Landois, *Die Lehre vom Arterienpuls.* Berlin, 1872.
[2] Moëns, *Arch. f. d. ges. Physiol.*, xx. p. 517, 1879.

10 mm.; the pulse was 70 per minute. Judging from the number and size of the elasticity waves, and especially from the distinctness of the wave due to closure of the aortic valves, the above curve, the one most frequently obtained in this patient, indicates a moderate degree of blood-pressure and arterial tension, and perfectly agrees with the existing alterations in the patient's circulation.

A considerable increase of tension is shown in another curve (fig. 4).

This was obtained during greater excitement, after walking, the use of wine, or a cold bath, sometimes also without obvious cause. Here there are four or five elasticity waves, and the wave of valve-closure is more distinct and nearer the summit, while the recoil wave is less marked. Marey's sphygmograph expressed these appearances thus (fig. 5).

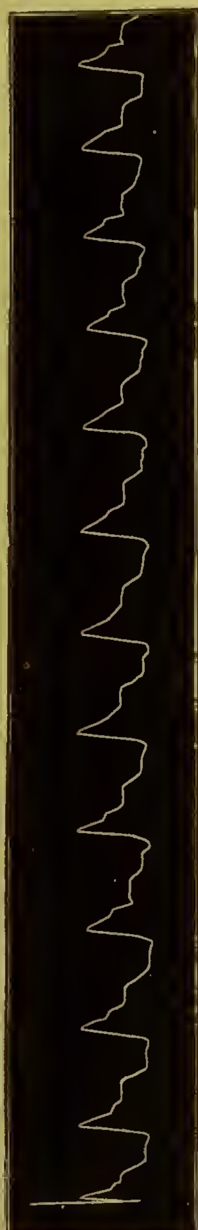


FIG. 3.

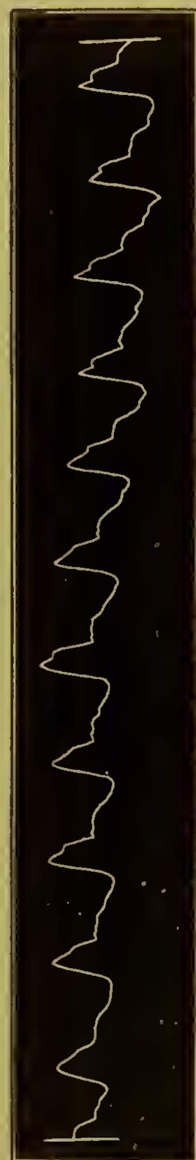


FIG. 4

The line of ascent is here somewhat steeper than in the foregoing; the summit and valve-closure wave are seldom separated, but the ascending line passes into the descending by a curve, enclosing both the above. The recoil wave is usually very flat, and two or three elasticity waves are apparent. The height of the curve is 7 to 7½ mm., the recoil wave being 4 to 4½ mm. below the summit. The length of the abscissa is 7 mm.; the pulse is 82 per minute. Like the others, this curve also indicates a moderate degree of blood-pressure and vascular tension.

Temperature.—The external temperature being 63·5° F. to 65·6° F., the axillary temperature averaged 97·7° F., and that in the mouth 99·1° F., the difference being 1·4° F.

Experiment II.

Aug. 2.—A three hours' walk on level ground.

Blood-Pressure:

At 8 A.M. before starting	= 135	mm. Hg	(pulse = 84)		
On returning at noon	= 147	,,	(pulse = 88 to 92 ;	increase = 12	mm.)
At 12.30 P.M.	= 145	,,	(pulse unaltered	,, = 10	,,)
After eating, at 1.30 P.M.	= 140	,,	(pulse = 96	,, = 5	,,)
At 3 P.M.	= 135	,,	(pulse = 84	,, = 0	,,)

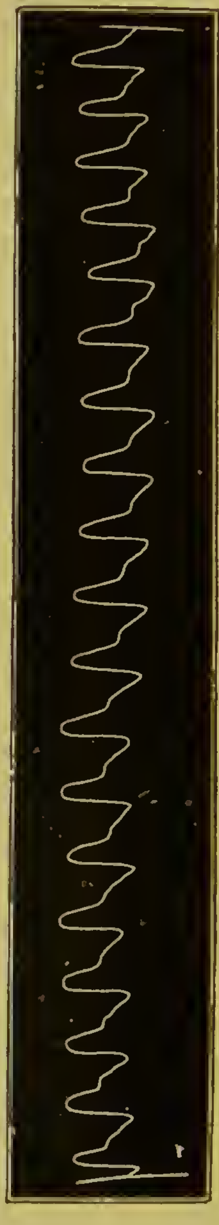
Arterial Fulness.—Temporal artery visible over the angle of the frontal bone for about 1 cm. as a roundish elevation $1\frac{1}{2}$ mm. high and 2 mm. broad. Trunk in temporal region more easily felt. Remaining appearances as in last experiment.

Arterial Tension.—The pulse-curve (fig. 6), taken by Marey's sphygmograph, rises as in fig. 5, and is 7·5 mm. in height.

The summit is again rounded off, and encloses the wave of valve-closure as before. But the recoil wave is now lowered to 6 mm. below the summit, and the elasticity waves are fewer and less marked. The abscissa is 7 mm. in length, the pulse being 87 per minute. Thus the curve alterations caused by a three hours' promenade on level ground show a distinct though slight decrease of arterial tension. Two hours afterwards the curve had resumed its normal form.

FIG. 5.

FIG. 6.



Temperature :

Before the walk,	in the axilla	= 97·7° F.	
,,	in the mouth	= 99·3° F.	
After the walk,	in the axilla	= 98·6° F.	Increase = 0·9° F.
,,	in the mouth	= 101·0° F.	,, = 1·7° F.

External temperature 65·6° F. Very sultry. Perspired much.

B. Ascents of Considerable Elevation.

Experiment III.

Aug. 7.—Walk from Fischhausen by the Spitzing pass to Wurzelhütte and the valley beyond, return over the Jägersteig to Brecher spitze. Time, including stay in Wurzelhütte, four hours.

Blood-Pressure :

8 A.M.	before starting	= 135 mm. Hg		Pulse = 84
10.30 A.M.	during the walk	= 178 ,,	Increase = 43	,, = 136
11 A.M.	while resting	= 140 ,,	,, = 5	,, = 106
1.15 P.M.	while returning	= 175 ,,	,, = 40	,, = 130
3.45 P.M.	after returning and eating	= 135 ,,	,, = 0	,, = 108

Arterial Fulness.—1.15 P.M. The temporal artery is visible in its whole extent, and its branches in the temporal and frontal regions can be made out over a pretty large area. At the lateral angle the artery forms a projection 3 mm. wide and $1\frac{1}{2}$ mm. in height. At 3.45 P.M. the artery showed the same fulness, but the branches were less distinct. Artery not quite so prominent. 6 P.M., the branches could no longer be seen or felt, but the trunk was still visible on the forehead, and was very distinct over the temporal region. At the above angle it was about 2 mm. broad and 1 mm. high. 8 P.M., return to the normal condition.

Arterial Tension.—1.30 P.M. The alterations in the pulse-curve (with Sommerbrodt's sphygmograph) are very striking (figs. 7 and 8).

The line of ascent is pretty steep, and 10 or 11 mm. high, and then it falls suddenly under a sharp angle to the base, the two limbs of the angle being here about 3 mm. apart. The curve then rises hardly 1 mm., often only half as much, above the base line, forms one or two, seldom three, small elevations or runs horizontally, and at a distance of 3·5 to 4 mm. from the descending limb ascends again to form the next curve. The valve-closure wave is absent altogether, or is only indicated by a very slight curvature of the descending limb.

The most striking characteristic of these curves is the almost total

disappearance of the recoil wave, and the descent of the downward limb completely to the base. The curve indicates a dicrotic to monocrotic, in part even a hyperdicrotic pulse. There is here then an extraordinary decrease of arterial tension, as first indicated in

FIG. 7.

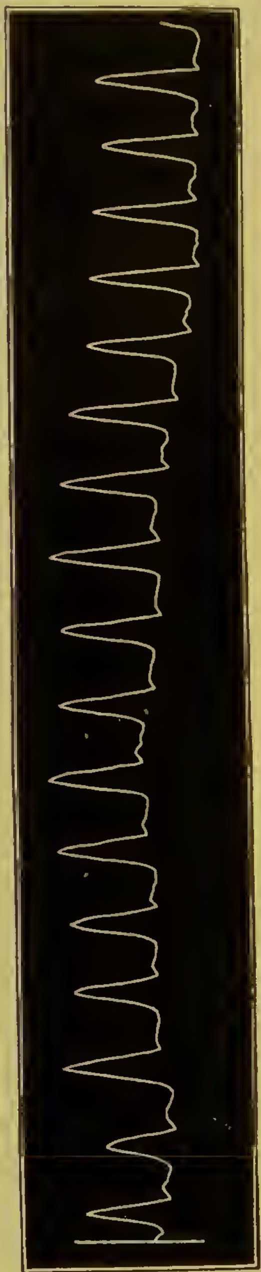


FIG. 8

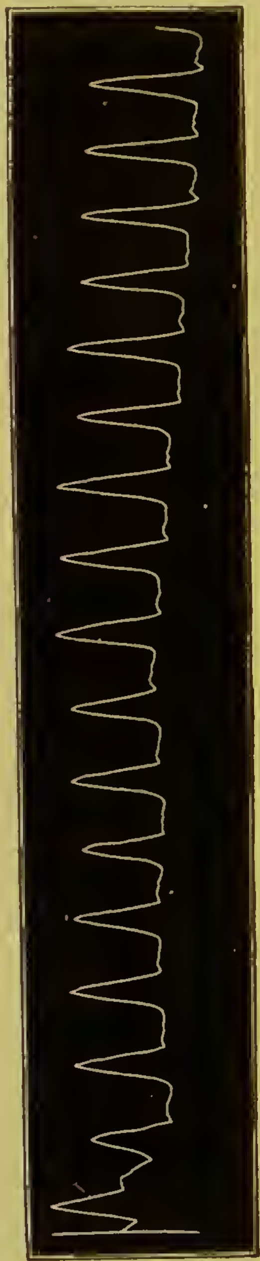


FIG. 9.

Exp. II. (fig. 6). These alterations proved extremely persistent, and did not disappear till long after all feeling of weariness had passed away; they could even be traced for many hours afterwards.

Fig. 9 curve was taken seven hours afterwards, at 8.30 P.M. The

primary wave no longer reaches its previous height (figs. 7 and 8), but is between 6 and 8 mm. high. On the other hand the descending limb sinks to within 1 mm. (less often ½ or 1½ mm.) of the base line, so that the recoil wave, though now evident, is still extremely small. But the elasticity waves are again prominent, and the valve-closure wave is distinct at almost every summit. The expedition of August 7 being begun at 8 A.M., the first hill ascended at 9.30, and the summit reached at 10.30, when the full effect of the ascent upon the circulation was already produced, this experiment shows the remarkable fact that the alterations observed in the pulse persisted at least nine and a half to ten hours, the whole vascular apparatus being equally influenced.[1]

Temperature:

In the axilla = 97·7° F.	After the ascent = 99·1°		Increase = 1·4°
In the mouth = 99·1° F.	„	= 100 7°	„ = 1·6°

Experiment IV.

Aug. 18.—Walk to Valepp and the valley beyond Spitzing. Start at 8 A.M., Spitzing pass reached 9.30, Wurzelhütte 10.10, rested fifteen minutes, Valepp reached 11.45. Food taken here at noon with a half-flask of Tyrolese wine. Return commenced at 1.45 P.M., Weitzingeralm reached at 2.30, Wurzelhütte at 3.30. Stay here for one hour. At Neuhaus 6 P.M. Evening meal with about half a pint of wine. Fischhausen 8.30 P.M.

Blood-Pressure:

	at	8.0	A.M. = 132	mm. Hg		Pulse =	84
Spitzing pass	„	9.30	„ = 144	„	Increase = 12	„	= 124
Wurzelhütte	„	10.15	„ = 133	„	„ = 1	„	= 96
Valepp (before dinner)	„	11.45	„ = 130	„	„ = −2	„	= 114
„ (after dinner)	„	1.45	P.M. = 138	„	„ = 6	„	= 112
Weitzingeralm	„	2.30	„ = 133	„	„ = 1	„	= 116
Wurzelhütte	„	3.30	„ = 145	„	„ = 13	„	= 120
Neuhaus	„	6.0	„ = 138	„	„ = 6	„	= 112
Fischhausen	„	8.30	„ = 135	„	„ = 3	„	= 96

[1] Lortet, who also noticed a decrease of arterial tension during his ascents of Mont Blanc, ascribed it to the influence of the rarefied air, and believed that mountain-sickness might be partly explained by it. The erroneousness of this supposition is most convincingly shown in the above and the succeeding experiments. The decline of arterial tension must be looked upon as a direct effect of the ascent, as a compensation, and not as due to lower atmospheric pressure, which in the above case was scarcely altered. See M. L. Lortet, *Deux Ascensions au Mont-Blanc*, p. 25, Paris, 1869.

Arterial Fulness.—The temporal artery appeared much as in Exp. III., except that the changes were more persistent, being traceable up to 10 P.M. By next morning the artery had resumed its usual size.

Arterial Tension.—The pulse-curves (fig. 10) show an alteration in so far that the descending limb, after reaching the base of the curve, rises higher than in the previous figures ($1\frac{1}{2}$ to 2 mm. high), and thus forms a recoil wave to which a small elasticity wave often succeeds. Later determinations gave again the same curves as in figs. 7, 8, and 9.

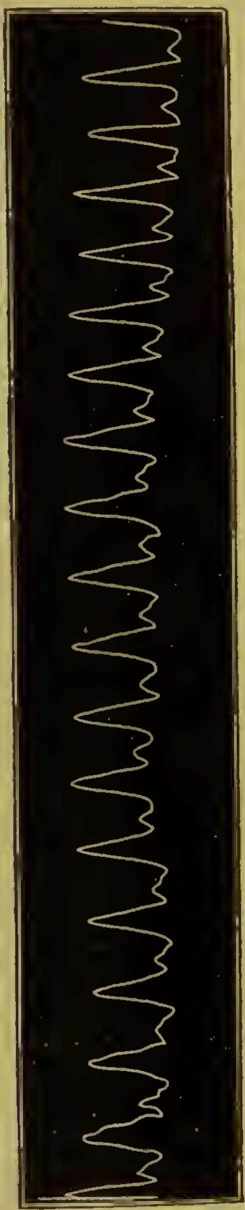


Fig. 10.

Temperature.—This was not determined.

Experiment V.

Sept. 11.—Walk to Valepp. Start at 8.30 A.M., Spitzing pass reached 9.40, Spitzing ascended in forty minutes, the usual time occupied being one hour, and the patient was not forced to stand still and rest once. No palpitation, no dyspnœa. Return to Neuhaus at 5 P.M.

Blood-Pressure :

At 8 A.M. = 125 mm. Hg. Pulse = 80.

On the Spitzing at 9.40 A.M. = 133, 128, 127, 129, 130, 129, 128, 130, 129, 132, 129, 128. Min. = 127 ; max. = 133 ; average = 129. Increase = 4 mm. Hg. (Pulse = 120.)

At Neuhaus, 5 P.M. Blood-pressure = 124, 124, 124, 125, 126, 125, 127, 126, 125, 125, 124, 123 mm. Hg. Min. = 123 ; max. = 127 ; average = 124·8. Increase = – 0 2 mm. Hg. Pulse = 116.

Arterial Fulness.—No special variation from Exp. IV.

Arterial Tension (Marey's apparatus used).—5.30 P.M. The curves obtained (fig. 11 *a*, *b*) are again characterised by increased length of the primary ascent, which is about 9 mm. high and almost vertical; then follows a blunt angle and a sudden descent. The rounded summit encloses the true summit and the valve-closure wave as in the other curves. This is well seen in fig. 11 *b*, where the last six curves show the summit and the above wave separated. At two or two and a half

mm. above the base the line is bent to form an imperfect recoil wave. The elasticity waves are only faintly marked in a few of the curves; the limbs of the curve at the level of the recoil wave are about $2\frac{1}{2}$ mm. apart. Length of abscissa 5 mm. Pulse 112.

The decrease of arterial tension is again most clearly shown in these curves, but there is less dicrotism than before. It is to be observed that in some of these curves (*b*) the wave due to closure of the aortic valves persists after the above alterations had appeared. The idea seems justified that this sign of increased blood-pressure and arterial tension is the last one to disappear. When the pulse was again examined at 10.30 P.M. the influence of the expedition still showed itself; the height of the curve was still 8 to $8\frac{1}{2}$ mm., and even 9 to $9\frac{1}{2}$ mm. in some cases; the recoil wave on the descending line was $2\frac{1}{2}$ to 3 mm. above the base. The angle at the summit (fig. 12) was now more acute; just below it came the valve-closure wave, with a second elasticity wave somewhat lower, and the recoil wave was more distinctly developed. Finally, below this last, elasticity waves appear on some of the curves. The curves given by Marey's instrument thus agree with those of Sommerbrodt's in indicating a considerably lessened arterial tension, and the decrease still

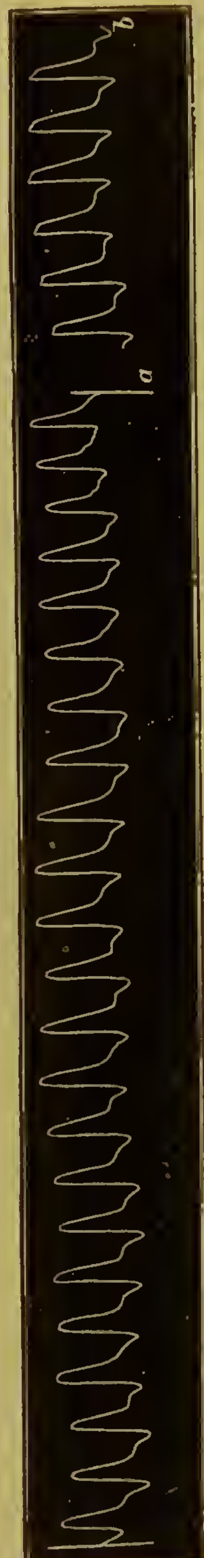


FIG. 11, *a* and *b*.

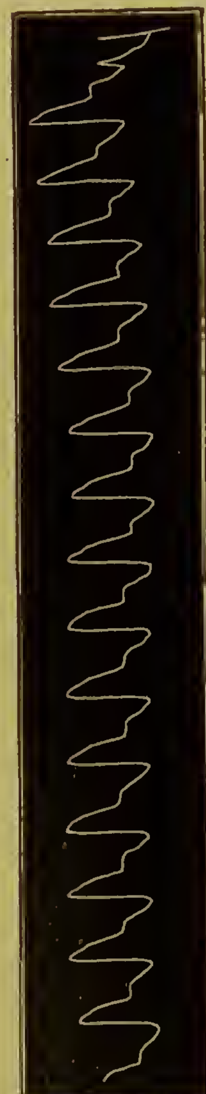


FIG. 12.

persisted, though in less marked degree, for five hours after the expedition.

By next morning the pulse-curve showed the usual form.

Temperature.—8 A.M. Temperature of chamber 61° F., in the axlla 97·7°, in the mouth 99·1°.

Temperature of air	In axilla	Increase	In mouth	Increase
9.10 A.M. Spitzinghöhe, 54·5° F.	98·7°	1°	100·7°	1·6°
5 P.M. Neuhaus, 61·1° F. . .	99·6°	1·9°	100·5°	1·4°

The cooling of the surface of the body in the evening in the valley at Neuhaus, at an external temperature of 61° F., was 0 9° F. less than on the Spitzinghöhe at a temperature of 54·5° F.

C. Mountain-Ascents.

Experiment VI.

Aug. 11.—Ascent of the Jägerkamp.

Start at 9 A.M. Jägerbauernalm reached 11 A.M., Spitze at noon, stay there of one hour. Return to Neuhaus at 3.30 P.M. Perspired profusely, but drank very little liquid.

Blood-Pressure :

8 A.M. before starting	= 135 mm. Hg		Pulse	88
11 ,, at Jägerbauernalm	= 162 ,,	Increase = 27	,,	120
12 ,, on the summit	= 159 ,,	,, = 24	,,	116–120
3.30 P.M. at Neuhaus	= 144 ,,	,, = 9	,,	120
6 ,, ,,	= 158 ,,	,, = 23	,,	96
8.30 ,, at home, after supper	= 142 ,,	,, = 7	,,	100

Arterial Fulness.—The fulness of the temporal artery and branches was already noticeable 768 met. above the valley (about 2,500 feet).

3.30 P.M.—Artery and branches visible in whole extent. At angle of frontal artery 3 mm. broad and 2 mm. high.

6 P.M.—Trunk as before, but branches less visible, and soon lost to view on the temple and forehead.

8.30 P.M.—Trunk still prominent, though to a less degree, being now 8 mm. wide and 1 mm. high at the usual place. Branches lost to view about $1\frac{1}{2}$ cm. from their origin.

10 P.M.—Trunk as in last case. No branches visible.

Aug. 12.—Trunk has returned to ordinary condition, as in Exp. I.

Arterial Tension.—The pulse-curve of fig. 13, taken with a Marey's sphygmograph on the summit of the mountain, is characterised by

the great height of the primary ascent, while the recoil wave is only expressed by an insignificant elevation at the foot of the descending limb. It is defined either as an independent elevation about the size of a small elasticity wave, or else it forms a small hook at the side of the descending limb, small elasticity waves being then added occasionally.

FIG. 13.

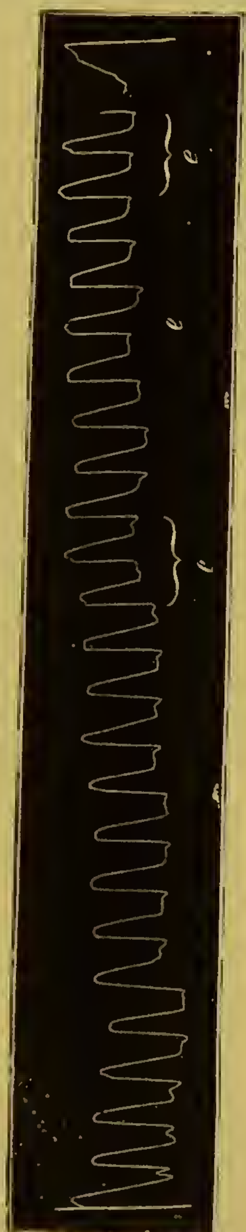


FIG. 14.

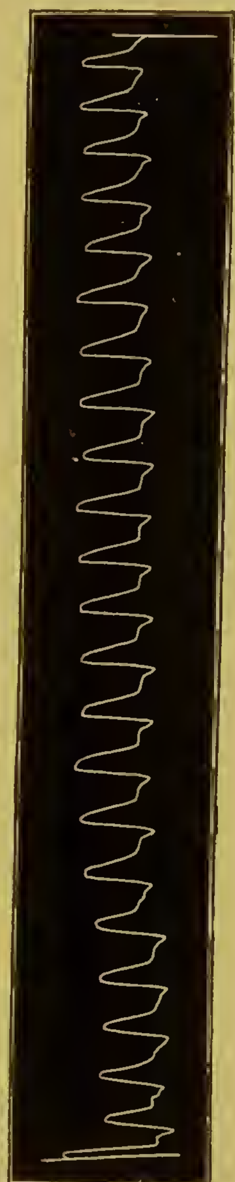
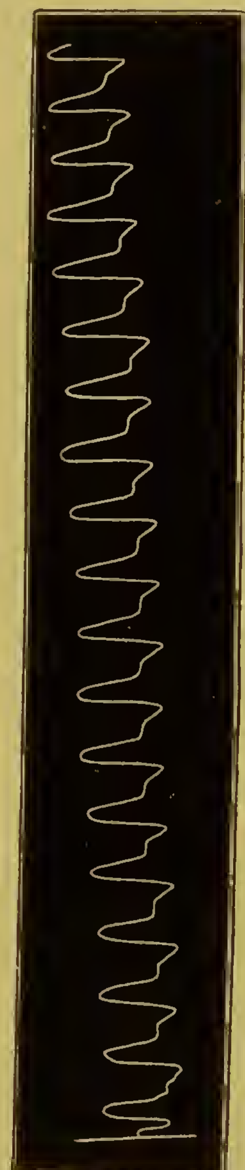


FIG. 15.



It is remarkable that at the summits of various curves (*e* in fig. 13) an anacrotic elevation is produced, so that the summit is clearly formed by three elevations : viz. (1) an anacrotic elevation ; (2) the true summit ; (3) the elevation due to closure of the aortic valves, the first katacrotic elevation.

The height of the primary wave is $7\frac{1}{2}$ to 8 mm., the height of the recoil wave $\frac{1}{2}$ mm., length of abscissa $4\frac{1}{2}$ mm. Pulse 120.

The curves (figs. 14 and 15) taken at 3.45 and 8.45 P.M. at Neuhaus and at home respectively, perfectly agree with those of Exp. V. (taken with Marey's instrument), and the reader is referred to that experiment for their explanation.

Temperature.—No observations were made.

Experiment VII.

Aug. 2.—Ascent of the Bodenschneid.

Start at 6 A.M., summit gained 8.45, return commenced 11.15, Neuhaus reached 12.30 P.M.

Blood-Pressure :

At 5.15 A.M.	= 129 mm. Hg		Pulse = 76
,, 12.30 P.M., Neuhaus	= 150 ,,	Increase = 21	,, = 120
,, 1.30 ,, at home	= 130 ,,	,, = 1	,, = 112
,, 3.30 ,, ,,	= 131 ,,	,, = 2	,, = 88
,, 9.0 ,, ,,	= 128 ,,	,, = −1	,, = 76

Arterial Fulness.—Increase in size of temporal artery and its branches somewhat less than in the last experiment and persisted a shorter time.

Arterial Tension.—No pulse-curves obtained in this experiment.

Temperature.—No observations made.

Experiment VIII.

Aug. 23.—Ascent of the Wendelstein.

In spite of its greater elevation, the ascent in this case was far less arduous than in the preceding, on account of the present good road. The amount of watery loss from the body by the copious perspiration was considerable. Three hours and a half were spent on the expedition.

The cause of the low values for the blood-pressure in this experiment (see opposite page) may be ascribed firstly to far less muscular exertion, secondly to the great loss of water from the skin and lungs, and finally to the greater and more persistent compensatory arterial dilatation, in consequence of the long ascent.

Arterial Fulness.—The increase in size of the temporal artery, as in Experiment V., reached its climax when the summit of the mountain was gained, 11 A.M. August 23, and persisted two hours. By 7 A.M. next day the artery was normal again. After a descent of two hours,

Blood-Pressure.—At Home (4.45 a.m.) = 125 Mm. Hg. Pulse 84.

Time and place	Blood-pressure in mm. Hg	Minimum	Maximum	Average	Increase	Pulse per min.	Remarks
Aug. 23, 11 A.M., summit	135 130 127 125 126 122 123 133 133 125	122	135	128	3	132	At 5 A.M. by carriage from Fischhausen to Bayerischzell
Noon, Wendelsteinhaus	132 131 132 129 126 132 128 130 130 128 130	126	132	130	5	116	—
1 P.M. ,,	130 133 134 125 132 130 130 126 134 130 129 127	126	134	130	5	112	After drinking 9 oz. of wine
2 P.M. ,,	115 117 115 124 122 126 128 129 131 130 131 133 130	115	133	126	1	108	Immediately after one hour's sleep
4.30 P.M. ,,	127 130 128 135 128 128 131 132 128 132 134 133	127	133	131	6	100	5 oz. of coffee and 7 oz. of water taken
7 P.M. ,,	132 129 129 130 127 125 133 127 129 132 131 131	125	133	130	5	96	—
Aug. 24, 7 A.M ,,	125 130 130 128 129 131 124 127 126 129 128 127	125	131	128	3	76	Before breakfast
Noon ,,	127 126 128 127 125 122 128 126 122 124 128 128	122	128	126	1	120	More climbing; 9 oz. of wine taken
2 P.M., Bayerischzell valley	134 127 123 123 126 125 120 127 124 129 124 130	120	134	126	1	20	Very quick ascent; external temp. very high; copious perspiration
9 P.M., at home (Fischhausen)	122 126 127 124 122 124 129 123 126 123 124 127	122	129	125	0	88	After supper, 9 oz. of wine taken

when the Bayerischzell valley was reached, the trunk and separate branches were again prominent to the sight and touch. 9 P.M. same day, at the usual site, the artery appeared still much dilated and well filled, and its course could be distinctly traced. No branches were visible. Next morning the artery was normal.

Arterial Tension.—No pulse-curves obtained.

Temperature.—No determinations made.

Experiment IX.

Aug 28.—Ascent of the Brecherspitze.

In consequence of the terribly neglected road, the blocks of granite to be climbed over, and the snow-drifts towards the summit, this ascent was extremely difficult and entailed much more exertion than the last. There was an enormous increase of work done, and the heart-muscle was forced into far greater activity. 7.30 A.M., ascent commenced. The road was at once steep and the weather sultry in the valley, causing much perspiration. Wind and cold from the Angelalpe onwards. Summit reached 10.15; home 1.30 P.M.

Blood-Pressure.

Place and time	Blood-pressure in millimetres of mercury				Minimum	Maximum	Average	Increase	Pulse	Remarks
7.30 A.M. Home	124	122	123	121	121	127	124	—	84	Before breakfast
	122	126	127	126						
	125	126	124	123						
10.15 A.M. Summit of the Brecherspitze	135	135	134	139	134	146	143	19	128	On reaching the summit
	139	145	138	145						
	146	138	138	142						
11.15 A.M. ditto	139	139	136	139	134	140	137	13	116	After eating some food, drinking 180 grms. wine, and resting one hour
	135	134	136	140						
	137	134	138	138						
1.30 P.M. Neuhaus	134	138	134	134	129	136	134	10	138	Very rapid descent. Perspired much
	135	136	134	133						
	129	132	130	135						
3.30 P.M. Home	135	130	127	129	125	135	128	4	104	After eating and resting
	130	125	126	125						
	126	128	130	129						
8 P.M. ditto	125	126	127	127	125	128	126	2	84	After supper, without any wine
	128	128	127	126						
	128	128	125	125						

Arterial Fulness.—Temporal artery as in Experiment VI., but the trunk remained large a longer time, and had not quite resumed its usual size at 9 P.M.

Arterial Tension.—The following curves (figs. 16 and 17) were obtained directly after returning home at 2 P.M., and the same alterations appear as in the preceding experiments. It may be noticed that the short recoil wave, at first independently developed at the foot of the descending limb of the curve, becomes more and more flattened, to an almost horizontal line hardly ½ mm. high, upon which one or two elasticity waves may often be recognised (monocrotic and hyperdicrotic pulse). The largest primary wave (under the same pressure as the rest, viz. 200 grammes) reaches 14½ mm., while the recoil wave at the base is barely ½ to 1 mm. high.

FIG. 16.

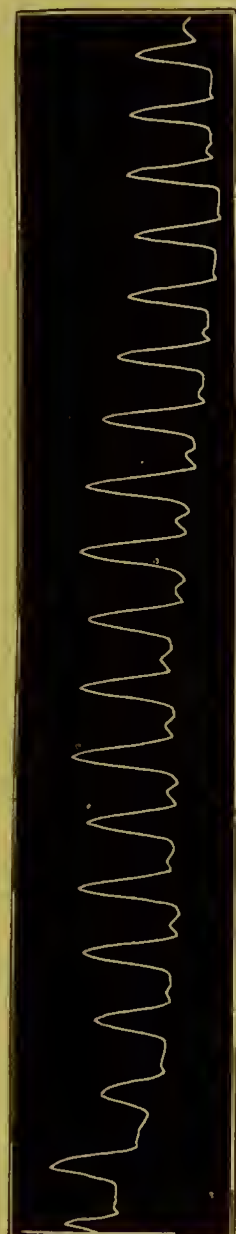
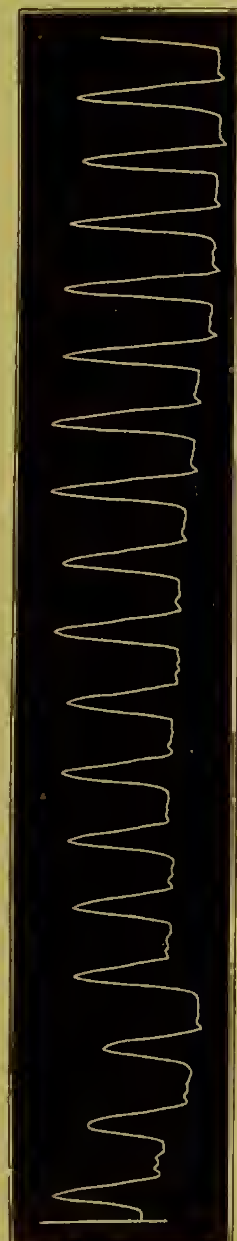


FIG. 17.



The curves obtained at 8 P.M. show that the vascular system was still under the influence of the recent exertion, and the effect of the latter was evidently very persistent. The curves of fig. 18 are still high, up to 11 mm.; the angle at the summit is still rather acute, and close beneath it is a curve representing the valve-closure wave. The

descending limb does not reach the base, but at a height of from $\frac{1}{2}$ to 2 mm. above it forms a small elevation, $\frac{1}{2}$ to 1 mm. high, so that the recoil wave is more perfect here than previously, and then falls gradually to the base, bearing one or two small elasticity waves. The decrease of arterial tension is thus less expressed in these waves than in the preceding.

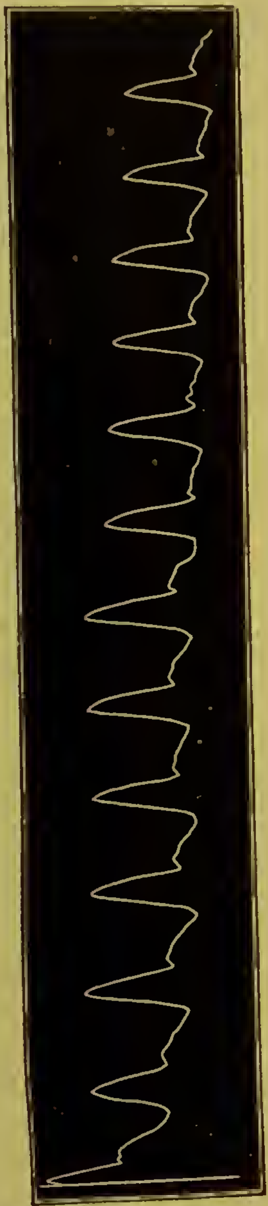


FIG. 18.

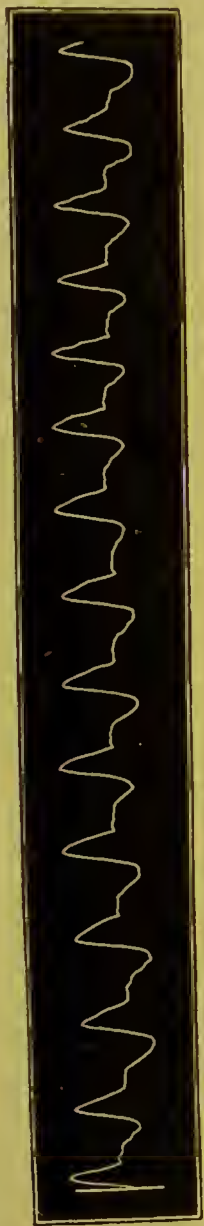


FIG. 19.

The curve obtained next day (fig. 19) at 8.15 A.M., *i.e.* $18\frac{1}{4}$ hours after the first curve and 22 hours after reaching the summit of the mountain, shows that the recoil wave is still lower down than usual, while the elasticity waves are of the usual diminutive size, and the height of the whole curve has returned to the normal. By midday the whole curve was quite normal again.

Temperature.—No determinations made.

Experiment X.

Sept. 4.—Ascent of the Rothwand.

The road lay over the Spitzing pass and the lower and upper Wallenburger-alm to the summit. Return over Grosstiefenthal and Geitau. Hence to Neuhaus by carriage.

Blood-Pressure.

Time and place	Blood-pressure in mm. Hg	Minimum	Maximum	Average	Increase	Pulse	Remarks
6 A.M. Home	126 125 125 123 126 128 127 127 124 124 125 126	123	128	125	—	84	Start at 6.45. A cold; down the Spitzing, very hard going
8 A.M. Spitzing pass	138 134 139 136 137 138 137 137 134 135 136 130	130	139	136	11	124	Stay here of $\frac{1}{4}$ hr. To Wurzelhütte in 20 min. Stay of $\frac{1}{4}$ hr.
9.50 A.M. The lower Wallenburgeralm	126 126 133 127 132 137 127 132 128 129 128 130 126	126	137	129	4	132	Severe exertion for 1 hr. Stay of 20 min.
11.55 A.M. Summit of the Rothwand	133 130 134 135 135 134 137 134 135 138 138 139	130	139	135	10	132	Stay here till 1 P.M.
1.45 P.M. Grosstiefenthal	133 134 137 138 134 132 135 131 134 133 135 137	131	138	134	9	132	Quick descent down a bad road, requiring care. Start hence at 2 P.M.
4.20 P.M. Level of Geitau	130 134 130 134 130 134 132 134 136 134 135 134	130	136	133	8	124	Stay in Geitau 25 min.
5.45 P.M. Neuhaus	130 135 133 129 130 129 128 132 133 130 127 126	126	135	130	5	116	From Wirthshaus by carriage to Neuhaus
9.20 P.M. Fischhausen	126 126 128 124 125 126 128 127 124 124 125 125	124	128	126	1	96	Some wine taken $1\frac{3}{4}$ hr. after supper

Arterial Fulness.—In spite of the cold there was a good deal of perspiration on reaching the summit, and the whole trunk of the temporal artery was much dilated. The same was the case on the lower Alm after $2\frac{1}{2}$ hours' walking. The temporal was still more distended on gaining the Rothwand after 4 hours' walking, and its branches were well filled. This condition persisted till Neuhaus was reached.

6 P.M.—Both trunk and vessels dilated and prominent over temple and forehead. Measured by compasses at the angle of the frontal bone, the artery was about 3 mm. broad and 2 mm. high. The branches could be seen for about 1 cm. and opposed resistance to the touch.

8 P.M.—Little alteration. Trunk still 3 mm. broad and $1\frac{1}{2}$ mm. high. Branches only visible for $\frac{1}{2}$ cm.

11 P.M.—Trunk still visible in high relief. Measurement as before. Branches only visible near their origin.

Sept. 5.—8 A.M.—Only at the usual angle is the artery slightly more prominent than the normal, over an extent of 1½ cm.; it is about 2 mm. broad and 1 mm. high.

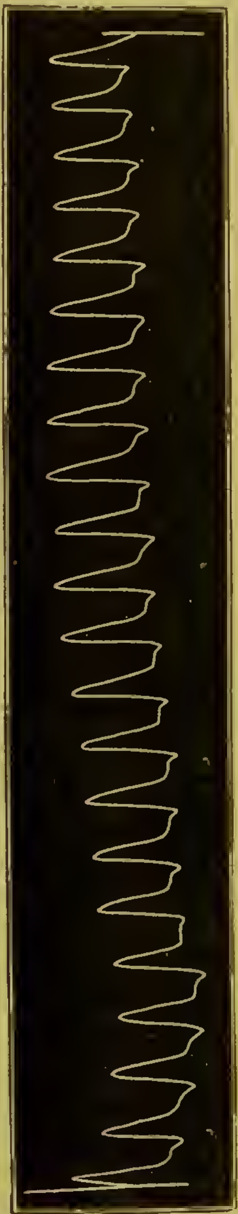


FIG. 20.

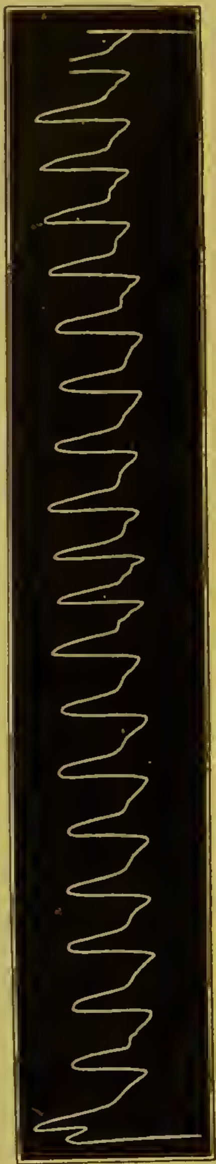


FIG. 21.

11 A.M.—Artery has quite returned to its ordinary size. See Experiment I.

Arterial Tension.—Pulse examined on the summit of the mountain with Marey's apparatus at 12.15 P.M.

The curve obtained (fig. 20) resembles that on ascending the Spitzing pass, except that the primary wave is somewhat higher (10 mm.) and its angle sharper. Pulse 120–24.

The curve obtained at 10 P.M. (fig. 21) still indicates considerable decrease of arterial tension and increased cardiac activity. The primary wave is almost as high as at midday, and falls at as sharp an angle towards the base, 2 mm. above which it curves to form the recoil wave, only slightly expressed. Besides the valve-closure wave just below the summit a few katacrotic elevations are seen at the foot of the curve.

The significance of these curves is the same as that of the earlier ones: they indicate *increased cardiac energy, increased arterial fulness, lessened arterial tension*, and a *quickened circulation.*

By next morning the ordinary condition was resumed.

Observations on other Persons.

a. The curves of fig. 22 were obtained on the summit of the Rothwand, from the pulse of a young man who had been there two hours already before our arrival. The pulse (88) is decidedly slower than our patient's, but the curves show a pronounced dicrotism. The primary wave shows a steep rise and a sudden fall under a very sharp angle nearly to the base; then comes a long, almost horizontal, course, which bears the first elasticity wave, succeeded by the recoil wave and a second elasticity wave. (Marey's sphygmograph.)

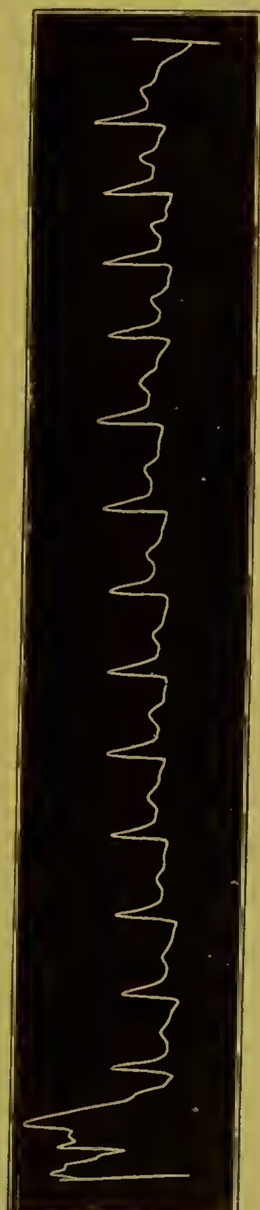


Fig. 22.

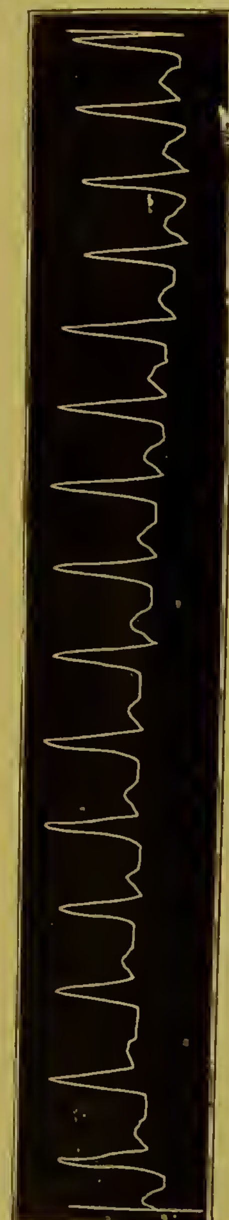


Fig. 23.

b. An equally fine representation of extremely lowered arterial tension is shown in the following curve (fig. 23), obtained from the pulse of a young physician who had just completed a most trying expedition, the ascent of the Rothwand, returning over the back of the mountain to Jägerkamp and descending. He had started at 10.30 A.M., reached the Rothwand at 2.15 P.M., and returned home at 5.45 P.M. The pulse was examined at 7.45 P.M. by Sommerbrodt's apparatus.

Temperature. — The determination of this was interfered with by the biting wind down the Spitzing. On the Passhöhe the external temperature was only 50.9° F. in the sun, and the wind persisted as far as the edge of the

Rothwand, where it was quite tempestuous, allowing us to stay there only a few minutes. The wind was strong in Grosstiefenthal also, and only ceased on our descent to Schellenberg. Thence to Geitau it was quite calm, with a pleasant warmth of 69° F.

Time and place	External temp. in °F.	Axillary temp.	Sublingual temp.	Increase		Remarks
				Axillary	Sublingual	
6 A.M. At home	65·6	97·8	99·2	—	—	—
8 A.M. Spitzing pass	50·9	97·3	100·1	−0·5	0·9	Surface cooled by a nipping wind
9.50 A.M. Lower Alm	65·6	96 8	101·0	−1·0	1·8	Remarkable cooling of surface, while the internal temperature was raised 1·8° F.
11.55 A.M. Rothwand	59·9	98·9	100·9	1·0	1·7	Axillary temperature now 1° F. higher than in the morning, and 2·0° F. higher than at the previous measurement. Sublingual temperature much the same as before
1.45 P.M. Grosstiefenthal	65·6	96·8	100·7	−1·0	1·5	Much surface-cooling again
4.20 P.M. Geitau plain	68·9	99·6	101·7	1·8	2·5	The high temperature here is due to the lessened cooling in the calm, together with increased heat-production, the vessels being much dilated by the four hours' continuous exertion
5.45 P.M. Neuhaus	65·6	98·6	99·9	0·7	0·7	The temperature is still high
9.20 P.M. Home	65·6	98·0	99·3	0 2	0·27	Temperature nearly normal

These observations do not agree with those of Lortet during his ascent of Mont Blanc. He states that the temperature was *lowered* 3·6° F. at an elevation of between 1,000 and 2,049 metres, *i.e.* about the height of the Rothwand (1,890 m.)

Temperature in ° C.

Place	Height in metres	Ascent of Aug. 17		Ascent of Aug. 26		External temp.	
		At rest	During exertion	At rest	During exertion	Aug. 17	Aug. 26
Chamonix . .	1,000	36·5	36·3	37·0	35·3	10·1	12·4
Cascade du Dard	1,500	36·4	35·7	36·3	34·3	11·2	13·4
Châlet de la Para	1,605	36·6	34·8	36·3	34·2	11·8	13·6
Pierre Pointue .	2,049	36·5	33·3	36·4	33·4	13·2	14·1

Although Lortet's temperatures were obtained under the tongue, some errors of observation must have crept in (at least at the above elevations), into which we cannot go any further. *Vide* Lortet, *op. cit.* p. 32.

Sept. 5.—The temperature was again normal, both on the surface and within the mouth.

To the above observations on alteration of blood-pressure, &c., during rest, walking, and arduous exertion, I may add another, in which the alterations of blood-pressure and arterial tension after much cooling of the surface was observed.

Experiment XI.

a. Investigation of the Blood-Pressure after Bathing in the Schliersee.

Aug. 26.—Temp. of water, 62° F. Time in the water=15 min. Moderate blood-pressure of 125 mm. Hg before bathing. Pulse 80.

Time and place	Blood-pressure in mm. Hg				Minimum	Maximum	Average	Increase	Pulse	Remarks
12 noon. Bathing house	141	139	140	135	134	141	137	12	72	Soon after the bath
	139	140	138	140						
	135	137	134	137						
3.30 P.M. At home	130	130	128	128	128	132	130	5	96	After a meal and slight exercise
	129	131	132	132						
	129	129	128	130						
9 P.M. At home	125	132	126	126	122	128	126	1	96	1½ hour after supper ¼ litre of wine taken
	124	127	128	128						
	127	123	125	127						

In this experiment the blood-pressure after a cold bath of 15 min. reached a higher degree than was obtained on the ascent of the Rothwand, but the measurement of the temporal artery was decidedly

less, the artery being small and contracted, the pulse at the wrist tense and hard. In Experiment X. there was a rise of blood-pressure with decrease of vascular tension and arterial dilatation, and both the latter factors induce lowering of blood-pressure, whereas in this experiment it was caused by *increase of tension* and *lessened size of the arteries.* Accordingly, in Experiment X. the blood-pressure and the quantity of blood in the arteries are absolutely greater than in Experiment XI., in spite of the higher figures given by the manometer.

b. Investigation of the Vascular Tension after an Ascent of the Rothwand and Quick subsequent Cooling.

September 11, 1882.—Start at 8.30 A.M. Summit reached 1.45 P.M. Return commenced at 2.45. Geitau at 5.15. Home by carriage 6 P.M. The pulse was examined at 6.30 P.M.

In the first series of curves (fig. 24) we find all the signs of a gradual elevation of arterial tension, succeeded by a gradual decline.

In this figure there is evident a very great rise of arterial pressure and tension, the basal line being bowed upwards. Besides the valve-closure elevation there is a second, so that the summit of the curve bears three eminences, and its shape reminds us of Landois's 'compensatory variations' with elastic tubes. At the same time the recoil elevation is raised, indicating also increased pressure and tension. Later on these appearances gradually subside; the curves sink again, though without reaching their original position; the separate curves show a distinct decline of arterial tension, and the pulse becomes dicrotic. In the second series, again (fig. 25), there is increased pressure, shown by increased prominence of the valve-closure wave and the higher elevation of the recoil wave above the base, though the pressure is not so great as in the first series. Finally, in the third series (fig. 26) everything indicates a steady lowering of arterial tension, and this decline persisted on later examination of the pulse.

The cause of this remarkable increase of pressure, the quantity of blood in the arteries remaining the same, must be ascribed to vasomotor excitation, due to rapid cooling of the surface of the body. The person experimented on had quickly

undressed on returning from the expedition, in order to determine the loss of water from the body by weighing, and his pulse was examined while still under the influence of the cooling. The arteries, and especially their terminal branches, were

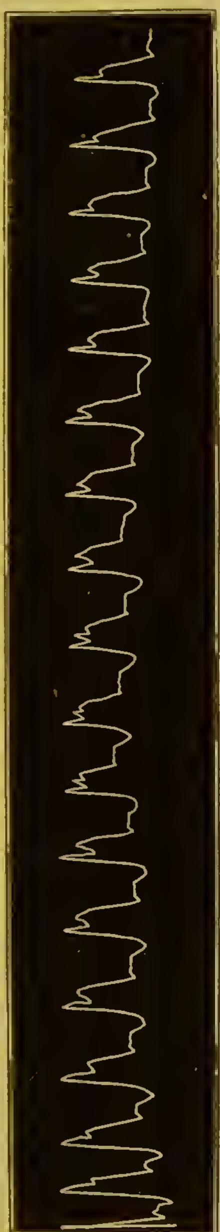


Fig. 24.

Fig. 25.

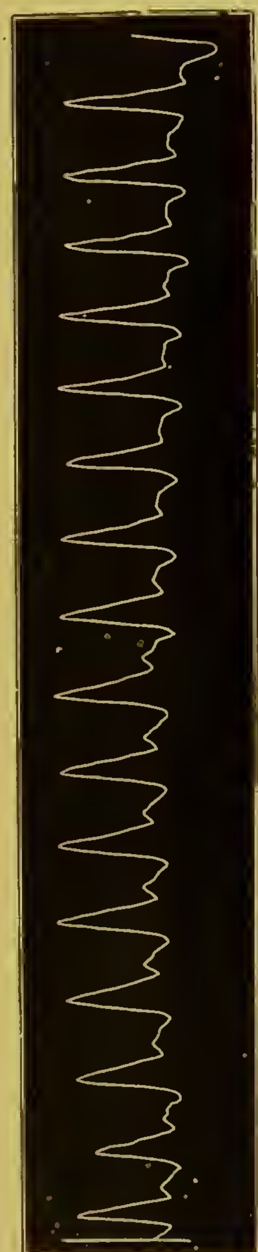


Fig. 26.

strongly contracted for the time, and thus their tension was increased. In consequence of the lessened flow from this contraction of the small arteries and capillaries, the same quantity

of blood was no longer transmitted in the same unit of time, and therefore the elevations at the summits of the curves appear as compensatory deviations like those obtained with elastic tubes, and more pronounced as the outflow tube is narrowed. It is further worthy of notice that, in spite of the above signs of contracted arterial walls, the primary wave is not only as high as usual, but often higher. The reason of this may be sought in the increased propelling capacity of the cardiac muscle, which to a great extent overcame the arterial opposition.

The greater elevation of the recoil wave above the base is the first expression of the increase of blood-pressure, and next to this comes the formation of the elasticity wave at the summit, regarded by us as due to the closure of the aortic valves. If the arterial wall be relaxed, the elasticity waves become less prominent, the recoil wave is lower down and smaller, the primary ascent is higher, the abscissæ are shorter. The vessel is more quickly and completely distended under the pressure of the blood, and the small recoil wave shows that a smaller quantity of blood flows backwards in the distended vessels at the end of each systole.

In the second series of curves we have no longer such a great increase of tension; the primary wave remains at the same height, only the valve-closure wave is more distinct and the recoil wave higher.

In the third series, however, vascular tension is steadily lowered, while the blood-pressure remains the same, being compensated by arterial dilatation and relaxation.

Thus the three series afford a picture of a part of the physical processes which occur in the vascular system under the sudden influence of lowered temperature, *i.e. chilling*.

Experiment XII.

The Influence of Increased Respiration upon the Pulse.

We have now to examine whether a rise of intra-bronchial pressure, caused by quickened and deepened respirations, causes any alterations in the pulse-curves, persisting after the respiration has returned to its usual course.

According to Hering's researches,[1] moderate distension of the lungs increases the frequency of the heart's action, as long as the pressure of the air does not exceed thirty to fifty mm. Hg. The quickening of the heart's action does not pass off with the discontinuance of the inflation. Knoll,[2] in his observations on the influence of the respiration upon the shape of the individual pulse-curves, has indicated two cases of mitral stenosis, in each of which a pulse that would be indicated as imperfectly dicrotic according to Wolff, became perfectly dicrotic, or even hyperdicrotic, on the patient's making a forced respiration. The pulse thereupon became quicker and fuller than in ordinary breathing, and the variations due to respiration were less marked—indeed, a slight lowering of the pulse-waves could be observed in the course of an inspiration. Knoll was unable to explain these alterations of the recoil wave in these two cases.

Sommerbrodt[3] has recently shown that a dicrotic or hyperdicrotic pulse is not only *caused* by increased respiration (singing in a different register, loud speaking, declamation), but persists for some time after these acts; and he endeavours to explain this by the excitation of sensory nerves in the lungs, following even a slight increase of intra-bronchial pressure. This sensory excitation, besides its reflex action on the cardiac-inhibitory nerves, is supposed by him to have a reflex depressing influence on the vasomotor nerves.

In order to estimate the influence which forced respiration exerts upon the pulse, our patient in different experiments made 25, 60, 75, 100, 150, and 200 deep respirations, several pulse-curves being taken immediately afterwards. The results varied somewhat. In many cases forced respiration influenced the pulse-curves unmistakably, but never to much extent, and in particular more transiently and lightly than was the case in Sommerbrodt's observations. Since this influence depends on nervous excitation, it depends very much upon the individual

[1] Hering, *Sitzungsberichte der kaiserl. Academie der Wissensch. Wien*, vol. lxiv. sect. ii.

[2] Knoll, 'Beiträge zur Kenntniss der Pulscurve,' I., *Arch. f. exper. Pathol.*, vol. xi. p. 403, 1878.

[3] J. Sommerbrodt, 'Die reflectorischen Beziehungen zwischen Lunge, Herz und Gefässen,' *Zeitschr. f. klin. Med.*, vol. ii.

whether such an experiment succeed or not, and some experiments on animals by Hering failed in spite of the observance of every precaution.

The most frequent result met with after even twenty-five deep respirations was lowering and flattening of the recoil wave; after persistent deep respirations to 150 or 200, the elasticity waves disappeared also, both those at the summit and those lower down the descending limb of the curve. That the first curve (fig. 27) bears no anacrotic elevation, that its highest portion forms the true apex of the curve, is well shown by the gradual disappearance of the elevation met with below it, an elevation which we must look upon as due to elasticity. A lowering of the recoil wave to the base of the curve—that is, the formation of a perfectly dicrotic pulse as well as a quickened cardiac action—was not found in any experiment. The consequences of deepened respiration were thus limited in these experiments to a moderate but never decided *lowering of arterial tension*, with consequent lowered blood-pressure.

Fig. 27.

From these results, only a moderate share in the production of the above pulse-curves can be ascribed to the influence of increased respirations. It was the mechanical act of locomotion itself and the physiological processes therewith connected which mainly influenced the vascular apparatus. *The quickening of the circulation, and in particular the rapid flow of venous blood into the right heart, with the increased blood-pressure thereby induced*, which result during mountain-climbing, lead to an *excitation of the vasomotor centres* which is transferred to the *depressor nerves*, and is followed by *compensatory*

lowering of arterial tension and *arterial dilatation.* The long-continued influence of these factors renders possible the persistence of the vascular alterations observed after mountain-ascents or other strenuous exertion, and their graphic representation even many hours afterwards.

Experiment XIII.

THE INFLUENCE OF THE TURKISH BATH UPON THE PULSE.

It may interest us subsidiarily to subject to a closer examination the influence upon the vascular apparatus of the Turkish and vapour baths, and of pilocarpine injections.

The influence of the Turkish bath is altogether different from that which is exerted by increased work. The marked and persistent lowering of arterial tension observed after the latter, together with the increased cardiac activity and arterial fulness, are never met with after the Turkish bath. Even if *during* the bath the pulse be dicrotic and the tension lowered (as Kisch [1] shows, there is arterial dilatation even in a simple warm bath), nevertheless a quarter of an hour *after* either the Turkish or vapour bath there is found a considerable rise of arterial tension (figs. 28 and 29). The pulse is not seldom anacrotic, and in the descending limb of the curve (fig. 30) there appear some elasticity waves, besides an elevation of the recoil wave.

The artery is much contracted, its elasticity is increased, and its lumen is diminished. No gradual connection between the greater prominence of the above curves and the amount of watery loss could be traced in either kind of bath.

Pilocarpine injections caused similar pulse alterations. The lowering of arterial tension and pressure after this drug have been often proved by the investigations of Kahler and Soyka,[2] Leyden,[3] Sommerbrodt,[4] &c., and the same observers have also shown the transient character of its influence on

[1] Kisch, *Grundriss der klin. Balneotherapie.* Vienna and Leipzig, 1883.

[2] Kahler and Soyka, 'Kymographische Versuche über Jaborandi,' *Arch. f. exper. Pathol.*, vol. vii. part vi. p. 460.

[3] E. Leyden, 'Ueber die Wirkungen des Piloc. mur.,' *Berl. klin. Wochenschr.*, 1877, No. 27.

[4] J. Sommerbrodt, *Deutsche Zeitschr. f. pract. Med.*, 1877, p. 41.

the heart and pulse. The results I have obtained are similar to these. My curves mostly resembled those of Leyden and Soyka, and I have never witnessed any great influence on the pulse.

Fig. 28.

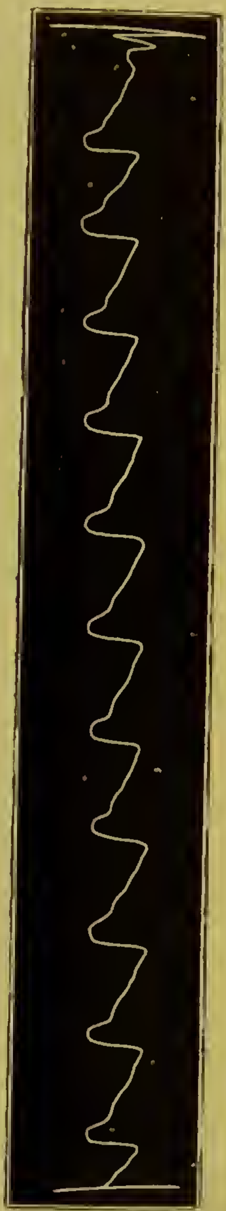
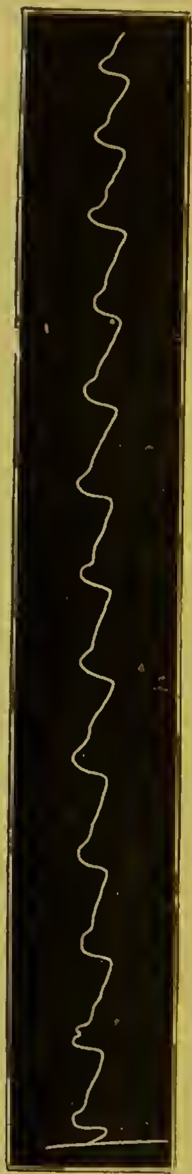


Fig. 29.

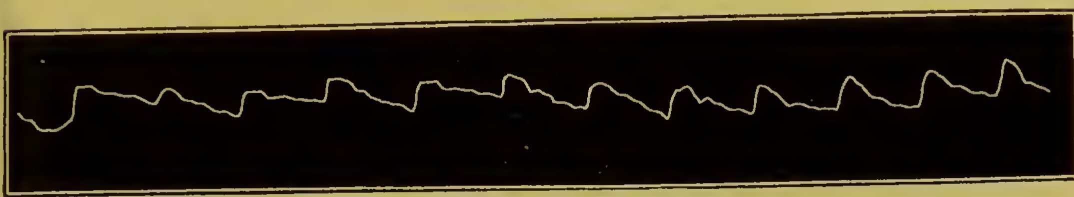
Fig. 30.



Moreover the duration of this influence has been quite transitory, and the alterations in the artery disappeared with the subsidence of the pilocarpine symptoms. I often noticed also that with the cessation of sweating and salivation, instead of the return of the pulse-curve to normal, there appeared

anacrotic elevations and an increase of the elasticity elevations (fig. 31)—appearances which indicated greater contraction of the muscular coat and a narrower calibre, but these signs had all disappeared half to one hour later on.

FIG 31.



From these observations it is evident that the influence of sweating-baths and of pilocarpine upon the heart-muscle and nerves can find no application in the problem set before us, and the value of these therapeutic means lies wholly in the loss of water from the body which they occasion.

GENERAL RESULTS OF THE ABOVE EXPERIMENTS.

Now let us glance at the results of these experiments :

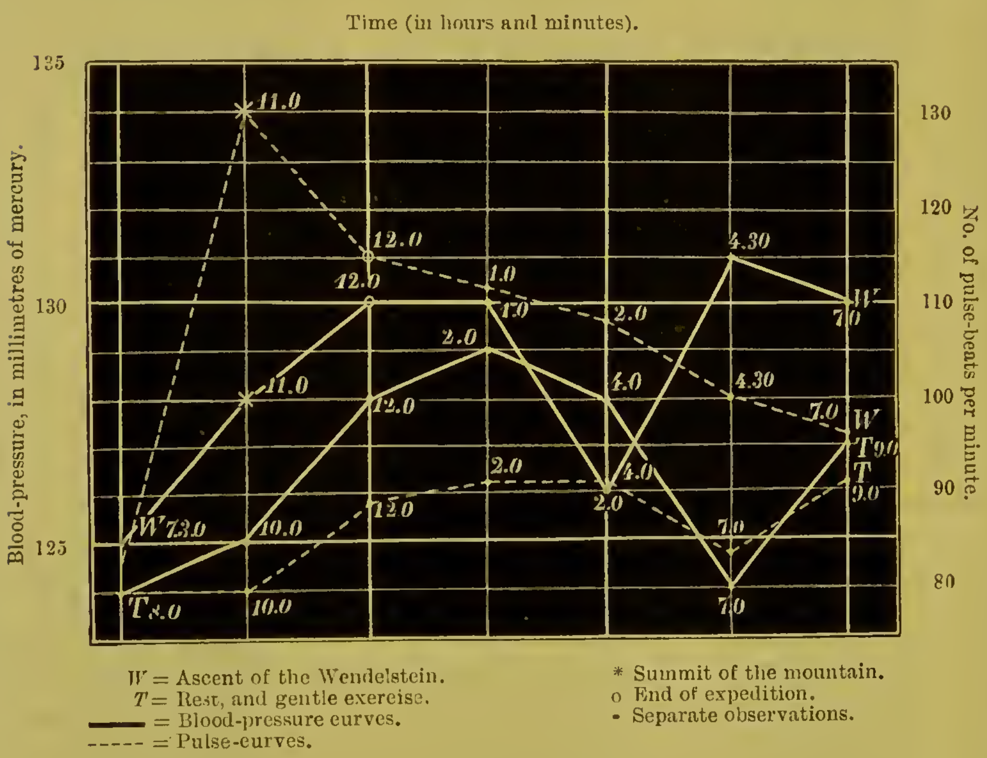
The first consequence of persistent locomotion with increased cardiac excitation, *i.e.* of mountain-ascents, is *increased blood-pressure*, the increase being greatest in persons unaccustomed to such work.

This increase of blood-pressure is accompanied, owing to excitation of the depressor nerves, by *vascular dilatation*, with *lowering of arterial tension* and *increased volume of blood in the arteries.* The arterial dilatation and increased fulness cause a greater amount of heat to be given off, both by the skin and within the body, which may be shown by the thermometer. The development of heat within the body itself is furthered by the increased combustion due to strenuous muscular work. The increase of blood-pressure is compensated by the lowering of arterial tension and by the arterial dilatation.

Owing to this compensation we obtain only relative values in our estimations of blood-pressure, and the absolute degree of this, supposing a normal arterial tension and calibre, must far exceed what is indicated by the sphygmo-manometer. If we graphically represent the blood-pressure values obtained during

the ascent of the Wendelstein and the day afterwards, with the daily variations of blood-pressure given in Experiment I. (rest and moderate movement), we obtain two curves (fig. 32, *W* and *T*), which do not apparently differ essentially; and yet the values expressed by the first curve (*W*) are far greater absolutely than those of the second (*T*). In the former the blood-pressure, in spite of the powerful depressor influence at work (arterial dilatation and lowered tension), rises even beyond the usual height, while in the latter a considerable proportion of the observed rise is due to the smaller calibre and greater tension of the artery.

FIG. 32.

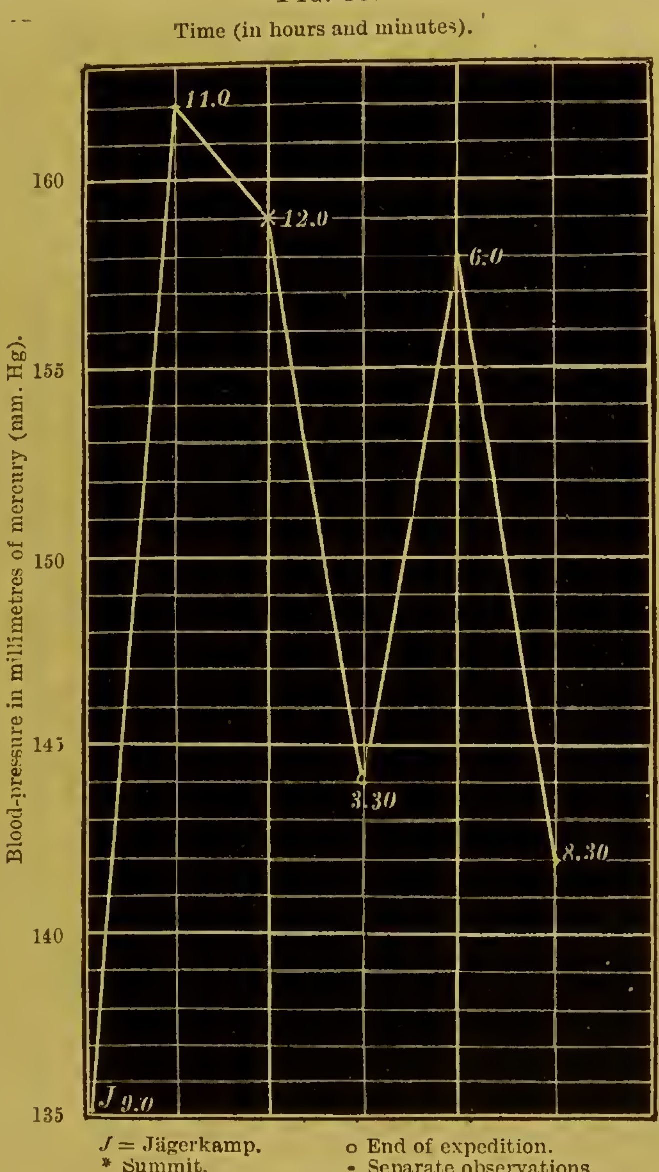


On the other hand, the two dotted pulse-curves (*W* and *T*) show most strikingly the great difference in the circulation.

But besides the compensatory influences due to the nervous system, the blood-pressure was still further lowered by its decrease in volume owing to the enormous watery loss from the skin and lungs—a loss which amounted, supposing the supply of water to the blood to be restricted, to 1½ kilo. and more—*i.e.* from one-fifth to two-fifths of the total amount of blood.

The blood-pressure does not rise *pari passu* with the height and duration of the ascent, but, other relations being the same, undergoes a decline, so that the degree of blood-pressure at the summit may be smaller than during the ascent. This is shown in Experiment X., where on the top of the Spitzinghöhe the blood-pressure was 136 mm. Hg, but after an hour's further walking (to the lower Wallenburgeralm) was only 128, and even on the summit of the Rothwand, 750 metres higher, was only 135 mm. Hg. On the other hand, the *muscular work* caused by mountain-climbing has a direct influence upon the rise of pressure. The worse the road, the severer the ascent, and the more strenuous the consequent effort, so much the higher is the blood-pressure; while if the road improve it may decline even with continued walking. In this respect Experiment VI. (fig. 33, ascent of the Jägerkamp) may be compared with Experiment VII. (fig. 34, *Br*, ascent of the Brecherspitze, with a blood-pressure of 143 mm. Hg). In the former, after Jägerbauernalm had been reached by a stony and troublesome road, the blood-pressure rose to 162 mm. Hg,

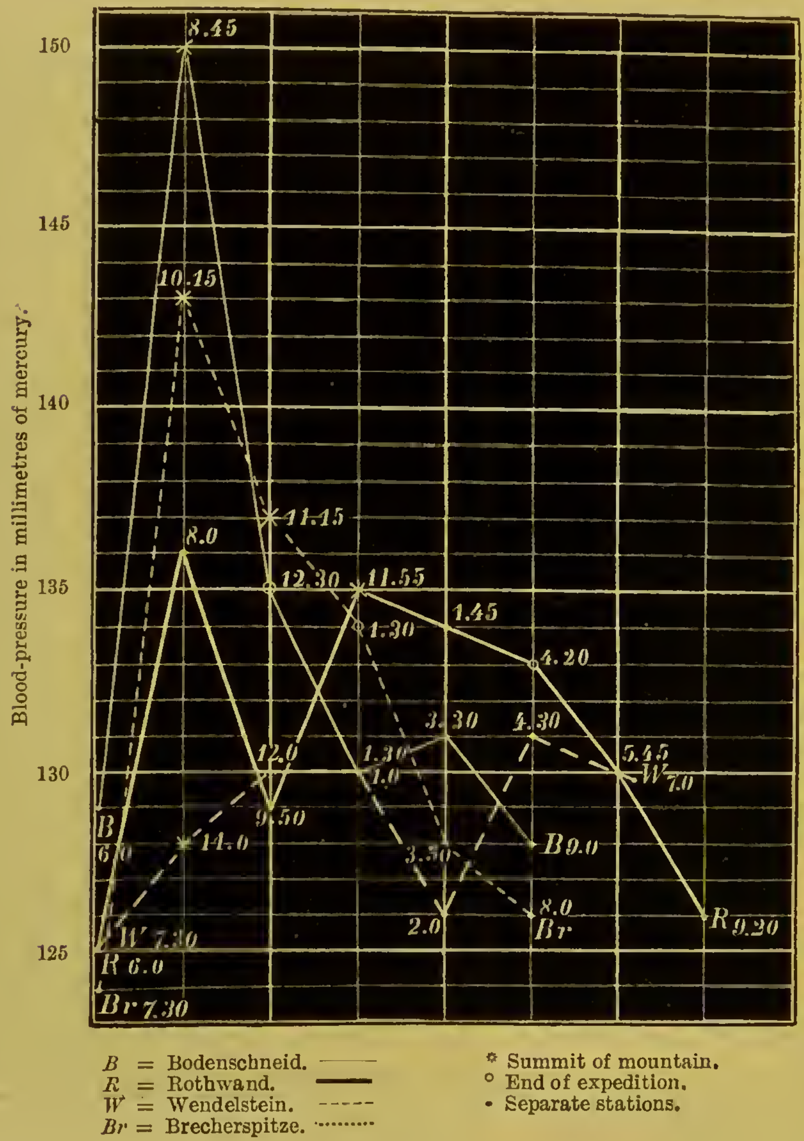
Fig. 33.



whereas from thence to the summit with an easier road it fell to 159.

So also the small rise of blood-pressure in Experiments VIII. and X. (fig. 34, *W* and *R*, ascents of the Wendelstein and Roth-

FIG. 34.



wand), in comparison with that in Experiments VI. and VII. (figs. 33 and 34, *Br*), is evidently the consequence of the lessened muscular work (in spite of the long ascent), together with the persistent lowering of arterial tension and the lessening of the blood-volume.

The increasing feeling of lightness during long ascents, and the small dyspnœic excitation in comparison with the evidently much increased action of the heart and the difficulty of breathing on first commencing the ascent, are explained by the compensation of the increased blood-pressure by arterial dilatation (the blood being now richer in hæmoglobin), and by the removal of water from the blood through the skin and lungs.

Further, if we compare the different ascents of the Spitzinghöhe, between which the above expedition occurred, besides a number of trying walks to Tegernsee, Tyrol, &c., not mentioned, we find on the first ascent an increase of blood-pressure amounting to 43 mm. Hg, which on the second ascent sinks to 12, on the third to 11, and on the fourth is only 4 mm. above the original condition.

The explanation of this case lies only in the *sudden* vascular dilatation, which allowed an easier transmission of the increased volume of blood pumped onwards by the heart. This dilatation doubtless became persistent through the long-continued ascents, *i.e. the vascular tone maintained by the vasomotor centre was permanently lowered, and the arteries carried more blood throughout*; as a consequence of this, the venous congestion which existed in the patient was compensated in part. This is shown in the first place by the decline of the blood-pressure, which in the beginning of August was 135 mm. Hg, but in September was lowered to the moderate amount of 125 mm. Hg; and, secondly, by the total disappearance of the cardiac symptoms, the palpitation, the embarrassment of the right ventricle, and the dyspnœa which used to set in even on starting the ascent, as the last experiments showed.

Date	Blood pressure in mm. Hg			—	
	At home	Spitzinghöhe	Increase	Neuhaus	Increase
August 7	135	178	43	175	40
„ 18	132	144	12	138	6
September 4	125	136	11	130	5
„ 11	125	129	4	124·8	−0·2

To this persistent influence of depressor-excitation, as well

as to the progressive diminution of the blood-volume, owing to the increased watery loss from the skin and lungs (which in these experiments was never compensated by the water supplied, as the weight of the body showed), we must also ascribe the great difference between the blood-pressure in the early ascent of the Spitzinghöhe and that which existed later, on ascending far higher mountains, as graphically shown in fig. 34.

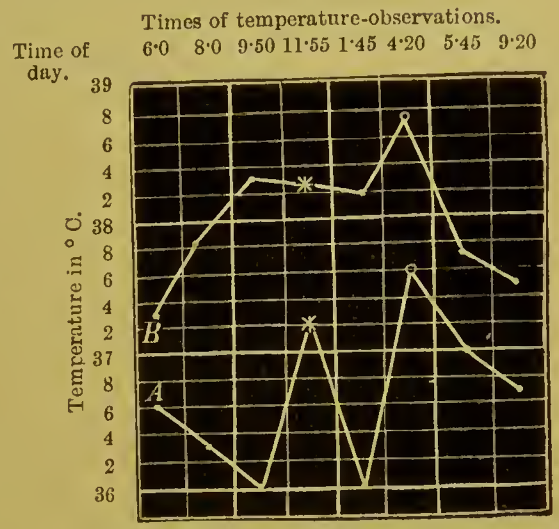
Quick strenuous walking on level ground also raises the blood-pressure, and, as the tables before us show, this increase may even be greater than that which occurs in severe ascents, such as those of the Wendelstein and Rothwand. But, on the other hand, the decrease of arterial tension (judging by the pulse-curves) and the expansion and filling of arteries, as shown by the temporal artery, are much less with the former—indeed, not far from normal. The increase of blood-pressure is here again really dependent upon the high vascular tension and the lessened vascular capacity, while the cardiac contractions are less energetic and the arterial fulness (and consequently the balance between the arterial and venous systems) is less perfect than in ascending mountains. Movement on level ground cannot, therefore, be substituted for the latter in the correction of circulatory derangements.

As to the *duration* of the increase of blood-pressure, it is, on the whole, but short, and quickly declines as the cardiac activity becomes less, while the compensatory vascular dilatation persists and lessens the blood-pressure. A few hours after the exertion, as a rule, the blood-pressure has already regained its average height.

In contrast to the blood-pressure, the *arterial dilatation* caused by excitation of the depressor nerves stands in direct relation both with the *length of time* expended on the exertion (the mountain-ascent) and the *amount of effort* put forth. The dilatation is at its greatest at the end of the work, provided this be continued with equal energy throughout; and since it still persists during the repose following such exertion, when the cardiac excitement has already passed away, we must regard it as due to *temporary lowering of the vascular tone preserved by the vasomotor centre.*

Like the lowering of vascular tone, *the increase of temperature* of the body, both superficially and internally, is proportional, other things being equal, to the amount of exertion undergone, but it quickly declines when this is over. It does not, however, regain its usual level at once, but remains slightly raised above the normal for several hours (Experiment X., fig. 35, end of experiment 5 hours). The cause of the first phenomenon lies in the lessened heat-production when the work is over; the second (the persistence above the normal) is due to the increase of heat formed, and given off by the dilated vessels.

Fig. 35.



A = Temperature in axilla.
B = Temperature in mouth.
* Summit of the mountaiu.
o End of expedition.
• Separate observations.

Further Conclusions.

By these facts the question we started with is answered, viz. how the heart and arteries behave in derangement of the hydrostatic balance and venous stasis, when by forced locomotion a rapid flow of blood to the right heart occurs. The venous blood forced into it in greater volume and under higher pressure by the violent exercise, and especially by the mechanism of ascents, is driven into the aortic system by cardiac contractions not only quicker but effected with far greater propulsive power, as shown in the preceding investigations by the increased frequency of the pulse, the elevation of the primary wave of the pulse-curve and the blood-pressure.

It is self-evident that corresponding changes must be effected in the conditions as to space of the circulatory organs, to facilitate these changes in the movement of the blood and to permit of its quickened flow. Through the powerful and involuntary respiration caused by hill-climbing the thorax enlarges in

all its dimensions, the *lungs* attain their *utmost possible respiratory distension*, and from the *enlargement of their vessels* are able to receive far greater quantities of blood. The intensity of the respiratory movements, which are conducted with all the strength possible, causes the aspiration of more blood into the thorax, and especially to the peripheral parts of the now distended lungs; the exit of blood from the right heart is thus facilitated, and the difference of pressure between the pulmonary artery and veins is increased.

By these processes in the lungs, however, part of the hindrances exciting and keeping up the circulatory derangement are removed, and the circulation becomes freer. Inasmuch as for a long time after each ascent the thorax has a greater mobility and expands more easily, so the alteration in the pulmonary circulation also outlasts the period of the ascent; and by repetition of these muscular exertions we are enabled to bring about a permanent increase of the capacity of the pulmonary vessels by increase of thoracic mobility, enlargement of the thoracic space, and increase of pulmonary capacity.

Finally, as already mentioned, the arteries of the greater circulation undergo considerable decrease in tension. In consequence of the relaxation of its muscular coat the artery expands easily in all directions, but especially in its transverse diameter under the increased blood-pressure, and thus carries more blood. But since the driving power of the heart is increased, while the resistances diminish, the blood-pressure remains approximately the same as before or alters *pari passu* with the latter, but the circulation is more rapid.[1] By this circulatory influence the equalisation between the arterial and venous apparatus is completed. More blood flows out of the venous apparatus, which is now unloaded; the blood-pressure and blood-volume in the veins are less, and the arterial volume increases.

Since the pulmonary vessels now take up more blood, more is arterialised and passed into the aortic system, and the oxyhæmoglobin increases, or rather approximates again to the normal proportion. More oxygen is afforded to the tissues, and the oxidation-processes, more or less in abeyance, become

[1] Rollet, *Physiologie der Blutbewegung*, p. 301.

normal once more. The large amount of oxygen required in the muscular work of mountain-ascents is thus sufficiently provided, and the previously defective decarbonisation of the blood, with its accompanying dyspnœa, is now perfectly corrected.

III. INFLUENCES AFFECTING THE HEART-MUSCLE.

We must now examine into the mechanical influences of mountain-climbing upon the heart itself, with the resulting consequences; and this is the most important part of our problem.

Almost without exception in cases of circulatory disorder coming before us with derangement of the hydrostatic balance, we find a weak, badly nourished, atrophied heart, partly infiltrated by fat, partly degenerated, and able to perform its work only imperfectly. In such cases, moreover, the earlier compensations, which in some degree mitigated the circulatory derangement, have gradually failed. How will such a heart be affected by an unwonted amount of work?

Up to the present time there lie no special investigations on this subject before us, important as it is. In investigating these more hidden processes we must bear in mind—

1. That in dealing with the heart we are dealing with a *muscle*, the relations of which as to nutrition and growth are the same as those of other muscles;

2. That the nutritive processes and functional capacity of the heart may be influenced by exciting and increasing its activity, just as other muscles are gymnastically strengthened and enlarged by exercise.

Accordingly, if we were to find a means of slowly and methodically increasing the heart's action, we should necessarily gradually raise its functional capacity, and induce an increase in size (under appropriate nourishment). But muscular activity displays itself in the expenditure of the force peculiar to it—*i.e.* in setting free contractions, stronger or weaker. If, then, we can induce strong and thoroughly effective cardiac contractions for a sufficient period, we induce an exercise of its force-expenditure, as with any other muscle, and

raise its functional capacity; and if we seek to effect a methodical excitation of such contractions, we must institute a *gymnastic, or course of exercise, of the heart-muscle.*

The most powerful and numerous contractions of the heart are obtained, according to its condition as to strength and pathological excitability, by the *ascent* of more or less considerable *heights*, most of all by *mountain-climbing.* There are no means whatever of procuring such persistently powerful cardiac contractions as this exercise entails.

Granting that our voluntary muscles, those of the limbs *e.g.*, are strengthened and enlarged by use, it might still be asked by some whether by this means we can attain the aim proposed, the strengthening of the heart-muscle. *Theoretically* nothing can be urged against this truly *gymnastic method*, but whether its *practical* carrying out is followed by the desired result is not to be decided *à priori.* On referring to facts as to the influence of mountain-ascents upon the heart we meet with the observation that by such exercise, by a life amongst the hills, there occurs a gradual hypertrophy of the heart. This alone might appear to justify us in selecting this method, were it not for the objection that in the cases where cardiac hypertrophy has resulted from a life among the mountains we are dealing exclusively with healthy, strong hearts, the nutrition of which has never been deranged, hearts which can bear very well the increased work. But in the cases before us we have a highly diseased heart-muscle, loss of the earlier compensations, and most severe circulatory disorder, to be overcome by strengthening the heart-muscle and re-establishing compensatory hypertrophy.

Under the régime followed hitherto, which enjoins perfect repose and plentiful nutrition with the usual amount of liquids or even more, and in which the threatening break-up of the patient is combated by purely symptomatic means, his case is hopeless, like that of thousands before him. The question is whether the contrary method, exercise and the simultaneous removal of water from the system, will succeed better or not. No records of such therapeutic measures are at hand, and it would be useless to enter into theoretical considerations. The problem is clear and simple. Whether a weak heart can be

made stronger and a lost compensation be restored by gradually exciting powerful contractions—*i.e.* by increasing cardiac action through gymnastic means—must for the present be regarded as an *experimental question*, only to be solved in an *experimental manner*, and the experiment before us gives the answer to this question.

D. *ALBUMINURIA AFTER INCREASED MUSCULAR ACTIVITY.*

The influence of muscular action on the excretion of albumen in the urine deserves special consideration.

The kidneys are more sensitive to circulatory derangements and *alterations of blood-pressure* than any other organs, whether caused by increased or lessened afference of arterial, or diminished efference of venous blood; and the escape of more or less albuminous fluid from the renal capillaries is almost always the consequence of such alteration of pressure. On the other hand, it is to be observed that the kidneys readily accommodate themselves to altered hydrostatic conditions in derangements which are not too far advanced, or which are partly compensated or only very slowly progressive, and up to a certain limit they continue to fulfil their functions approximately normally.[1] These facts are of extreme importance therapeutically. The possibility is thus afforded, if a balance between the arterial and venous pressures can be effected, of maintaining the renal functional capacity *within certain limits*, and of delaying for a long time the onset of inflammatory and nutritive disturbances, when they cannot be prevented altogether.

Albuminuria is accordingly not to be looked upon altogether as purely pathological. The glomeruli may transmit more or less albumen in perfect health, to an amount not exceeding 0·1 per cent., at different times, and its presence escapes observation because at these times the urine is not examined for albumen, or again, too great dilution of the urine may render its detection difficult or impossible. During the digestion of copious meals there is slight albuminuria in many persons;

[1] Senator, *Albuminurie*, p. 54.

also, after deprivation of food, chills, strenuous exertion, and mental disturbance, if elevation of pressure in the aortic system long persist, albumen may occasionally be found in the urine.

Vogel[1] first drew attention to the fact that in many persons albuminuria may exist uninterruptedly for years, without the appearance of casts or any other signs of renal disease, and without apparent illness.

Ultzmann[2] also, in eight cases of perfectly healthy men, mostly medical men, found albuminuria up to 0·1 per cent.; and amongst Dr. Guéneau de Mussy's[3] cases two medical men are mentioned who had albuminuria for twelve and fifteen years respectively, which did not impair an unusual activity, and the attainment of a considerable age.

Leube,[4] in 1878, published the results of his examination of the urine of healthy men. The urine of 119 soldiers was examined in each case, both that passed in the morning before exercise, and that at midday after severe exertion. The morning urine in only five cases (=4·2 per cent.) held albumen, the midday urine in nineteen cases (=16 per cent.) Leube, therefore, concludes that in by far the majority of cases the urine of healthy men is free from albumen, but that in a few individuals (4 per cent.) there is very slight albuminuria, not exceeding 0·1 per cent. in amount. The cases of albuminuria became relatively frequent after severe exertion.

Dukes[5] later on published ten cases of albuminuria in boys, from thirteen to seventeen years old. There were no symptoms present, except at most some debility, peevishness, dyspepsia, or headache, and no signs of organic disease anywhere, especially renal. Want of food, chill, and exertion induced or increased albuminuria; it disappeared on a milk diet.

Moxon,[6] Morley Rooke,[7] Saundby,[8] and Dr. Marcacci,[9] have

[1] J. Vogel, 'Krankheiten der harnbereitenden Organe,' Virch. *Handb. der spec. Path. u. Ther.*, vol. vi. sect. ii. p. 522.

[2] Ultzmann, 'Mikroskopisch-chemische Diagnostik der verschiedenen Formen von Albuminurie,' *Wiener med. Presse*, 1870, No. 4, p 81.

[3] Guéneau de Mussy, *Clinique Médicale.*

[4] Leube, *Virch. Arch.*, vol. lxxii. p. 175.

[5] Dukes, 'The Albuminuria of Adolescents,' *Brit. Med. Journ.*, Nov. 30, 1878.

[6] Moxon, *Guy's Hospital Reports*, 1878.

[7] Morley Rooke, *Brit. Med. Journ.*, Oct. 19, 1878.

[8] Saundby, *ibid.* May 10, 1879.

[9] Marcacci, *ibid.* May 10, 1879.

reported similar cases. The last-named made the observation on himself, that the urine passed during the day was seldom free from albumen, while the night urine was always free from it. He could even induce albuminuria by powerful arm-movements, which raised the pulse from 75 to 150.

Edlefsen[1] always found albuminuria after exertion, in three weak anæmic persons, while none was found after resting.

Fürbringer,[2] amongst fourteen cases examined, mentions three of weak anæmic individuals with albuminuria, which disappeared or at least diminished after rest, but which appeared or increased after exertion. In three other cases, albuminuria was accidentally discovered in three strong healthy young men. In these three cases the albuminuria could not be traced to exertion, but in another case, that of a busy medical man, aged 29, it was found up to 0·3 per cent. or even 0·6 per cent. after mental depression or much mental excitement. Moderate exercise had no influence on it, severe exertion produced it. After existing for eight months, the albuminuria declined, and finally disappeared altogether after a mountain tour of some weeks.

The same observer also undertook systematic investigations in sixty-one children, aged from three to six years, in a public institution. In seven there was distinct albuminuria, in four of these only on one or two occasions, more frequently in the other three, during a long period of observation. Albumen was seldom found after midday, but more often in the forenoon, and it generally coincided with a lessened quantity of urine and greater concentration.

Munn's[3] observations in America belong here, on persons about to insure. Amongst 200 applicants for insurance albuminuria was discovered in no less than twenty-four, *i.e.* in more than 11 per cent., without apparent cause. Munn states that there was often no albumen in the morning urine, and that it appeared most frequently in the forenoon.

Finally, E. Bull[4] has published cases of albuminuria in healthy

[1] Edlefsen, 'Ueber Albuminurie bei gesunden Nieren,' *Mittheilungen für den Verein schleswig-holsteinischer Aerzte*, Aug. 1, 1879.

[2] Fürbringer, *Zeitschr. f. klin. Med.*, vol. i. part ii. 1879.

[3] J. Munn, *Albuminuria in Persons Apparently Healthy, with the Proper Method for Detecting it*, March 29, 1879.

[4] E. Bull, 'Om kombinerte Bright'ske sygdomme,' *Nordiskt Med. Arch.*, vol. xi., *tredje och Gjerde häftet.*

persons and so has Dr. G. Johnson.[1] One case observed by Bull was that of a student, who occasionally found albumen in his urine some time after rising, never on first getting up. *Exercise appeared to have no influence at all on it,* and occasionally it disappeared for a time; the usual amount was 0·1 per cent. No organic disease was present, certainly no cardiac derangement; his body was well-formed, and his appearance healthy.

On seeking to explain the occasional occurrence of albuminuria in apparently healthy persons, the most natural supposition is that of a congenital permeability of the glomerular membrane (Leube). In the vast majority of healthy people the very slight permeability of this membrane, and the functional activity of the glomerular epithelium, prevent the passage of colloid substances. This resistance is not the same in everyone, but varies with the individual. Leube divides into two categories those persons in apparent health who have albuminuria, according as it occurs after bodily exertion or not.[2] In the latter category of cases of physiological albuminuria any idea of an abnormal renal circulation must be put aside, for we are speaking of individuals at rest and in health. Under these circumstances there remains nothing to explain the occurrence of so striking a phenomenon, but to assume some congenital abnormality of the glomerular membrane, or defective epithelial changes and the like; so that the normal capacity of the glomerular vascular wall to prevent the transition of albumen from the blood is lowered in such persons.

In the other category there is also abnormal permeability of the vessels and epithelium, but in spite of this they are usually able to prevent the transition of albumen under usual conditions. They lose this property, however, when a greater strain is put upon them, especially when the individuals undergo severe exertion. To explain why this should favour albuminuria in some persons and not in others is at present impossible.

Against this purely mechanical explanation we must bring

[1] Dr. G. Johnson, 'Latent Albuminuria, its Etiology and Pathology,' *Brit. Med. Journ.*, Dec. 13, 1879.

[2] Leube, *op. cit.*

forward Rosenbach's hypothesis,[1] viz. that the kidney is a *regulatory* organ which, when the blood is surcharged with albumen, or, owing to alterations in the blood-forming organs, has a lower capacity for taking up and assimilating it, is able to *excrete the excess* of unfixed (unoxidised or unoxidisable) albumen. Accordingly albuminuria is not due to disordered renal activity owing to abnormal blood, but is the expression of the regulatory function of the normal kidney, by which the blood is restored to its normal concentration, or is freed from superfluous matter. That the products of albumen-destruction, whether inflammatory products, or any other results of pathological albumen-disintegration, may, like infectious matter, appear in the urine, there can be no doubt. But how far the kidney is active here, and the albuminuria the result of a regulatory function and not itself a pathological condition, requires further investigation before it can take rank as an hypothesis. It is certainly *not* the function of the *kidney* to separate the excess of albumen from the blood. The feeding experiments with eggs speak decidedly against such a function. For instance, one dog took 423·1 grammes of egg-albumen, *i.e.* three or four times as much as his own blood contained, without a trace of it being secreted by the kidneys. Egg-albumen was taken also by persons up to 64 grammes without causing increase of existing albuminuria. As regards this question, therefore, the mechanical explanation of Leube must have the preference.

The influence of *alterations of blood-pressure* upon albuminuria has been shown experimentally in various ways: by increased and lessened afference of arterial blood, by restricted efference, and by pressure of accumulated urine upon the renal vessels, by tying the ureter. The results of those experiments alone in which the renal circulation was directly altered interest us.

1. Elevation of arterial pressure.

Attempts to induce albuminuria by raising the arterial pressure have been extremely unsuccessful.

The albuminuria caused by electric excitation of the cervical

[1] O. Rosenbach, 'Zur Lehre von der Albuminurie,' *Zeitschr. f. klin. Med.*, vol. vi. part iii. p. 240, 1883.

spinal cord, or by tying the carotids, or aorta itself, must be ascribed to some other cause than increased pressure in the renal arteries. In the former case, as Grützner[1] has shown, the albuminuria depends on spasm of the smaller arteries caused by electric excitation, while in the latter it is probably a consequence of irritation of the vasomotor centre when the carotids are tied (Nawalichin[2]) and of injury to the splanchnic nerves when the aorta is tied. In the latter experiments, moreover, the result is often contradictory. M. Hermann[3] and Knoll,[4] after section of the renal nerves, have only observed albuminuria from injury to neighbouring structures.

Lastly, the albuminuria which Senator caused by rapid and long-continued elevation of the temperature of the body—an elevation varying from 1·5° C. to 3·0° C.—may be otherwise explained than by simple elevation of blood-pressure. There remains then only the albuminuria observed after muscular exertion as the solitary evidence for its dependence on increased pressure in the aortic system.

In view of these facts, Heidenhain[5] regards it as improbable that in normal kidneys an elevation of the intra-glomerular pressure from increased afference of blood can cause albuminuria.

2. Lowering or cessation of the renal arterial supply.

While albuminuria has not been induced hitherto by experimentally increasing the arterial flow to the kidneys, and elevation of the arterial pressure within them, *it is easily caused by lessening* or *cutting off altogether the blood-supply.* Even after temporary closure of the renal artery for eight or ten minutes, there is a distinct trace of albumen in the urine. This has occurred through the glomeruli, the tubules appearing to be still intact and only sharing in the albumen-excretion after long-continued arterial closure.

Moreover, a persistently *diminished* blood-supply from

[1] Grützner, *Pflüger's Archiv*, vol. xi. 1875, p. 370.
[2] Nawalichin, *Centralbl. f. d. med. Wiss.*, 1870, p. 483.
[3] M. Hermann, *Wiener akad. Sitzungsber.*, 1861, xlv. p. 317.
[4] Knoll, *Eckard's Beiträge zur Anat. u. Phys.*, 1870, vi. p. 39.
[5] R. Heidenhain, 'Phys. der Absonderungsvorgänge,' *Handb. der Phys.*, by Hermann, vol. v. 1, p. 371.

considerable narrowing of the renal arteries, allows the transition of albumen through the glomeruli—as Hermann and van Overbeck observed—even while the arterial supply is diminished, and the urine consequently much lessened in volume. An admixture of blood was only found exceptionally in this form of circulatory disorder.

3. Partial or total obstruction of the efferent venous flow from the kidneys.

Only those experiments on venous stagnation, in which the venous efference is but *temporarily* interrupted, have any import here.

Ludwig[1] was the first to experiment in this manner, and he showed that by closure of the renal veins, the arterial supply being uninterfered with, the uriniferous tubules of both the cortical and medullary regions are compressed by the dilated veins about them, even till they are completely blocked, and the urine ceases to flow from the kidney till the circulation is free again. If the kidney be examined after venous obstruction for only a very short time, there is found at first merely great dilatation of the numerous cortical vessels, but no distinct signs of albuminuria can be found, certainly not in Bowman's capsules. If, however, the venous closure last eight to twelve, or at most fifteen, minutes small collections of albumen and shrivelled blood-corpuscles are to be found in the tubules, especially in the cortical substances and collecting tubes, while as yet no albumen-deposition has occurred in the capsules. In the latter it only occurs after persistent venous obstruction. According to the duration of the stagnation the epithelium of the tubules filled with albumen is either still attached to the basal membrane, or is already separated from it by a layer of coagulated albumen.

What is most important for us in these experiments is the fact that in venous stagnation caused by stoppage of the flow of venous blood from the kidneys, the arterial supply persisting, the medullary substance is the first to suffer, and the (abnormal) excretion of albumen occurs first in the *uriniferous tubules*, and only *later on* in the *capsules*.[2]

[1] Ludwig, *Wiener akad. Sitzungsber.*, xlviii. 1863.

[2] Senator, *op. cit.* p. 57

Much the same result follows *partial closure* of the renal veins, or tying the inferior vena cava, provided only that the venous obstruction do not persist too long. Senator thus explained the results obtained by Weissgerber and Perls in their experiments.

Such one-sided alterations of pressure as these above described, either in the arterial stream, the venous flow being unaltered, or *vice versâ*, scarcely ever enter into the pathology of circulatory disturbances. In the case of derangement of the hydrostatic balance, the correction of which forms our problem, *both the arterial and the venous pressures* have undergone alterations. In consequence of the circulatory obstruction, the insufficient cardiac activity and the deficient or failing compensation, the arterial supply is very much lowered, while, owing to the venous stagnation in the right heart, the renal veins can only imperfectly empty their blood, and the blood-pressure is raised even in the capillaries.

Moreover the restriction of the arterial supply to, and the venous flow from, the kidneys causes slowing of the renal circulation. Now Heidenhain[1] has shown that the rapidity of the renal excretion depends on that of the renal circulation, and, according to his investigations and justifiable objections against the filtration-theory, we must ascribe the excretion of urine from the glomerular vessels to the secretory activity of their enveloping epithelium. But the permeability of the glomerular vessels for albumen is thus made dependent on the *integrity of that epithelium*, which always perishes whenever the rapidity of the circulation (and therefore the oxygen-supply) sink below the limit necessary for its nutrition. The vascular region, therefore, from which the excretion of albumen occurred in the two series of experiments interesting us here, viz. diminished arterial supply to, and diminished venous flow from, the kidney, was in the former case the glomeruli, in the latter the uriniferous tubules of the medulla and the collecting tubes.

But the solution of our problem, does not in reality rest upon the still undecided question whether albuminuria occurs

[1] Heidenhain, *op. cit.*

by simple filtration as a mere consequence of alteration of pressure, or whether it is due to disturbed secretory activity from lowered rapidity of the circulation, and consequent lessened oxygen-supply to the epithelium of the glomeruli and uriniferous tubules. What we want to do is to restore the balance between the arterial and venous systems, though the consequences of this balance would be differently interpreted according to the hypothesis adopted.

The necessary requirements[1] then for the restoration of the renal hydrostatic balance will be—

1. Elevation of the arterial pressure by increased aortic fulness and increased blood-supply to the kidneys ;

2. Lowering of the venous pressure by increased outflow from the venous system generally and the renal veins in particular.

Our means of procuring these alterations in vascular pressure and fulness have been already given ; they lie in *increased muscular* (and especially *cardiac*) *activity* caused by *ascents and mountain-climbing.* We have shown by determination of the blood-pressure and arterial fulness and by sphygmograms the powerful influence which the cardiac activity caused by ascents exercises upon the heart itself, the vessels, and the circulation of the blood. Recapitulating the results obtained from these experiments, we have *increased energy of cardiac activity*, *arterial dilatation*, *diminished tension*, *increased*

[1] See J. M. Setschenoff, 'Zur Frage vom Blutkreislauf in den Nieren,' Wratsch, 1883, No. 8 (Russian), *Centralbl. f. d. med. Wiss.*, 1884, No. 3. [In the abstract referred to Setschenoff first draws attention to the shortness and large size of the renal arteries, their situation high up the abdominal aorta, and the consequent high arterial pressure in the kidneys, while on the other hand the venous pressure is very low, owing to the proximity of the renal veins to the termination of the inferior vena cava. Thus the chief regulating factor in the renal circulation is the great and constant difference between the pressures in the abdominal aorta and vena cava respectively. Hitherto the low venous pressure has been overlooked and variations in the amount of urine, *e.g.*, have been ascribed to variations of arterial pressure exclusively. The above relations explain how the hindrances to the passage of blood through the kidneys (the double capillary system) are overcome, the quickness of that passage (shown by the colour of the blood in the renal veins), the sensitiveness of the kidneys to alterations of venous pressure, and the large size of the renal arteries.—*Translator.*]

arterial fulness, and increased arterial blood-pressure (the last being partly compensated by vascular dilatation); while the flow of blood into the right heart is facilitated, the pressure in the venous system, especially in the inferior vena cava, is lowered, the stagnation is diminished or even done away with, and the rapidity of the circulation is increased.

On enquiring into the possible effect of mountain-ascents upon the renal circulation, we find that it may be twofold:

1. Increase of arterial supply to the kidneys;
2. Absolute or relative diminution of the same.

Both results must be regarded as the consequences of muscular work, and they show the influence of hill-climbing on cardiac energy and vaso-motor excitability.

A. Let us now suppose that the foregoing alterations observed in the aortic system during and after the ascent act *in toto* on the renal vessels, and let us consider those alterations in connection with the previous kidney derangements, the lessened arterial supply, and the restricted venous outflow, then we can estimate the kind and degree of the effect upon the blood-pressure and rapidity of the renal circulation, and consequently upon the albuminuria. Taking the extreme consequences of such circulatory alterations, we find—

1. That a great elevation of arterial pressure may possibly —there is no experimental proof, and Heidenhain is doubtful on this point—cause an excretion of albumen or the increase of an existing albuminuria. In reality this would be only a process which is already apt to occur physiologically, or rather, as the observations of Leube and others show, does occur in healthy subjects, and is merely increased in this case.

2. That by lessening the quantity of venous blood, on the other hand, an existing albuminuria, owing to the lowered pressure in the inferior vena cava and capillaries, and the consequent quickening of the renal circulation, is either diminished or temporarily made to cease. By the term 'albuminuria' here the purely pathological kind is meant.

Theoretically, therefore, an albuminuria from stasis would be increased as regards the glomeruli, and lessened as regards the renal veins and tubules, and the *plus* from one region would equal or exceed the *minus* from the other.

B. But against this increased arterial supply to the kidneys we must consider the opposite case—a diminished supply.[1]

Since in our experiments, not only during the ascents, but for a long time afterwards, there was increased cardiac action and arterial filling, which could only be accommodated by increased arterial capacity from lowering of vascular tone, so a diminution of the quantity of blood in the kidneys could only occur by contraction of the vessels in the region supplied by the splanchnic nerves. But the pressure in the renal arteries themselves would be raised still higher by this, and hence the renal supply might even be greater than the previous one, which was lowered by circulatory derangement and imperfect arterial filling. On the other hand the pressure in the renal veins would be certainly lowered, because of a quicker flow of blood in the inferior vena cava, and the increased thoracic and cardiac aspiration, so that the outflow from the kidneys would be much facilitated. The venous pressure in the kidneys would only be increased when the right heart was so overburdened during the ascent as to cause temporary congestion and dyspnœa, which scarcely happens when the ascent is properly conducted, viz. with frequent interruptions and long inspirations. That during dyspnœic excitation and momentary embarrassment of the breathing, the kidney becomes smaller and the arterial pressure higher, has been shown by Cohnheim's and Roy's experiments with the onkograph.[2]

Now by raising the arterial and lowering the venous pressure the renal circulation will be quickened, and although less urine is excreted on such expeditions, this is due, not to lowered pressure in the kidneys from increased muscular exertion, but mainly because the blood is less watery, owing to the profuse perspiration.

The urine amounts given on p. 181, as furnished in the extensive experiments of Dr. N., lend support to the above views. The circulatory conditions here presupposed all existed in the patient—viz. lessened arterial filling, lowered arterial pressure, increased venous

[1] See Ranke, *Die Blutvertheilung u.s.w.*, Leipzig, 1871, also Heidenhain, Senator, *op. cit.* p. 51.

[2] J. Cohnheim and C. S. Roy, 'Untersuchungen über die Circulation in den Nieren,' *Virch. Arch.*, vol. xcii. part iii. p. 437.

fulness, and high venous pressure. After several hours' exertion, including mountain-ascents, there were a significant increase of arterial fulness, *increased* arterial *pressure*, and *lowered* arterial *tension*; and, owing to these alterations in the blood-distribution and increased cardiac energy, also lowered venous pressure and quicker outflow from the right heart.

According to our assumption, such alterations would cause increased renal arterial pressure and *more blood would pass to the kidneys*, while at the same time the (renal) venous pressure would be lowered and the outflow facilitated. Hence not only would more excretory matter be carried to the kidneys, but, owing to the *increased oxygen-supply*, their *cellular activity* would be raised. In our case, consequently, *no particular diminution* of the urine was observed during severe exercise, such as mountain-climbing, and any reduction that occurred must be explained by increased density of the blood, owing to the excessive perspiration.

The results which here interest us in the above experiments are arranged in the following table :—

No.	Height ascended in metres	Time of experiment in hours	Average temperature in ° C.	Body-weight in kilos.	Total loss of weight in kilos.	Loss by urine in grammes	Loss per hour in grammes		
							Total loss	By urine	By skin and lungs
I.	—	$3\frac{3}{4}$	18·2	53,600	300	**136·0**	80·0	**36·3**	43·7
II.	—	3	13·2	53,200	350	**148·0**	116·6	**49·3**	67·3
III.	362	$3\frac{3}{4}$	28·7	53,550	1,104	**150·0**	294·4	**40·0**	255·2
IV.	362	$4\frac{3}{4}$	25·3	54,250	1,254	**191·0**	264·0	**40·2**	223·7
V.	957	$7\frac{1}{4}$	32·2	53,850	1,948	**222·5**	268·7	**30·6**	238·0
VI.	1,104	$9\frac{1}{2}$	22·7	53,600	2,056	**363·5**	216·4	**38·2**	178·2
VII.	768	6	22·1	53,320	1,475	**233·0**	245·8	**38·8**	207·2

The small amount of fluid imbibed by our extremely drained patient must be noticed, and the consequent small urine amount. (Vide p. 50 *et seq.* for food and drink taken during the experiments.)

The average quantity of urine passed per hour before midday was 30 to 37 grammes, from several investigations in Schliersee. In the first experiment, with $3\frac{3}{4}$ hours' rest, there were obtained 36·3 grammes hourly. In the other experiments, except the fifth, this quantity is exceeded, even considerably. In the second, in which the lowest average temperature in the open air (55·7° F.) was obtained, the urine amounted to 49·3 grammes per hour; and in the fifth, in which the average temperature rose to 90° F. in the sun, the hourly urine was 30·6 grammes, while the hourly excretion of water from the skin and lungs was 67·3 grammes in Exp. II., and

even reached 238 grammes in Exp. V. Thus in all the experiments an increase of urine was observed under the influence of exertion—*i.e.* of mountain-ascents—upon the morbid renal circulation. Herewith lessening of arterial supply, lowering of arterial pressure, and slowing of the circulation are altogether excluded.

With a more copious and less regulated liquid supply and excretion, under normal hydrostatic conditions, these processes could not be so easily overlooked.

If we imagine that the renal circulation is thus modified by mountain-ascents, we find that there is a decidedly *raised arterial pressure*, owing to increased cardiac action and increased aortic fulness together, and a *lowered venous pressure* (whereby alone could the amount of blood in the kidneys be possibly smaller), and any albuminuria, or the increase of an existing albuminuria, may, as in our first supposition, be set down to these changes.

The amount of such albuminuria, however, would leave it undecided how far the fundamental disorder of the renal vascular and secretory apparatus had been benefited or aggravated. Only *later on*, when the consequences of such influences had ceased to exist—viz. the supposed but improved excretion of albumen from the glomeruli, or the increase of an existing albuminuria, owing to increased arterial pressure during strenuous exertion—would the diminished albuminuria, together with other symptoms showing compensation of the former stasis, establish without a doubt that the mechanical correction of the circulation had affected the albuminuria as a consequence.

The immediate result of any particular experiment or of any series of such is of subordinate importance. Only an absolute diminution or cessation of albuminuria after severe exertion, would be direct evidence of a favourable effect on the renal circulation, and this result is not *à priori* to be expected. Moreover we are quite in doubt as to whether any, and how much, albumen is excreted after severe exertion, in healthy kidneys by the glomeruli, and in hydrostatic derangements and disease of the kidneys by the glomeruli on the one hand, and the uriniferous and collecting tubes on the other.

In order to determine the influence of mountain-ascents upon

the kidneys, or rather upon albuminuria, I made examinations of the urine of thirty-five healthy persons of the middle classes. I examined both the urine passed in the evening directly after the exertion, and that of the same night and next morning, and where necessary the urine passed during the next day was also examined. The persons were of various occupations and ages (from six up to fifty-eight years), and the exertion undergone was very great, viz. long walks amongst the neighbouring mountains near Fischhausen, the elevation being mostly between 1,000 and 2,000 metres—in one case more—above the valley-level.

Albumen was found only once in the thirty-five cases, and this not in the urine passed directly after the exercise (the ascent of the Wendelstein, 1,063 metres above the valley), but in that of the next morning. The albumen had disappeared by the evening of the same day, and was absent also next day. When the same young man undertook a smaller expedition, and ascended an elevation only 957 metres above the valley, no albumen was found in his urine, but it recurred when, at my request, he repeated the former ascent.

We must place this person in the category of individuals in whom the vascular walls and glomerular epithelium are abnormally permeable to colloid matters, but only under certain conditions. The albuminuria here is not simply a consequence of a mechanical alteration of pressure in the renal vessels, for otherwise it would have occurred directly after the exertion, but we must assume that, on the one hand, by the long-continued influence of muscular effort and increased cardiac action, the molecular composition of the glomerular membrane was deranged, causing a greater *porosity* of the same ; on the other hand, under the increased demands on the secretory activity of the cells for several hours under altered physical conditions, diminution and exhaustion of their functional activity finally set in. But these alterations in the vascular walls and epithelium had reached their acme when albumen could be no longer retained, and presently, when the effects of the exertion were over, a retrograde process occurred, so that the kidneys performed their functions normally even next day.

Hemialbumose was twice found: one case being that of a

man aged forty-two, who suffered from palpitation of the heart; the other person was a woman aged thirty-two, suffering from obesity and fatty heart.

In the boiled and acidified urine, a turbidity slowly formed on cooling, which disappeared again on warming; acetic acid and potassium ferrocyanide caused a flocculent precipitate after long standing. Unfortunately these cases could not be followed any further, and careful chemical investigation at the time was impossible. The history gave nothing important, and the individuals had always felt quite well. As to the relation between the hemialbumose and the previous exertion, we can only say that it will be the same as between albuminuria and the latter, and the appearance of hemialbumose instead of serous albumen is dependent on individual conditions which we do not as yet know. The cases must be simply registered for a time, as Ter-Gregoriantz[1] has done, who found hemialbumose in heart-failure, endocarditis, pleuritis, kyphosis, and after parturition.

It is further worthy of remark that after an exhausting walk, in which an ascent of 1,063 metres above the valley-level was made, no albuminuria was found in a boy aged only six and a girl aged ten; and that the health of these children was in no way injured by persistent exertion of no slight severity.

The percentage of albuminuria after mountain-ascents was thus only 3 per cent., while Leube placed it at 16 per cent. in healthy soldiers, *i.e.* 5·3 times as much. The persons whose urine I examined for albumen were quite unaccustomed to severe exertion and were not exceptionally strong; there were women amongst them and children as young as six years old. As regards bodily condition, therefore, the whole represents an equal number of unexercised soldiers such as Leube dealt with in his experiments. Mountain-climbing then acts in no way more prejudicially upon the kidneys than arduous exertion on level ground, while the *work done* is certainly not less than in military exercises, and the cardiac excitement and influence upon the blood-pressure and respiration are certainly greater. In the investigations with the sphygmo-manometer and the sphygmograph we proved the distinction between exercise on

[1] G. K. Ter-Gregoriantz, *Ueber Hemialbumosurie.* Inaug. Diss. Dorpat, 1883.

the level and mountain-exercise. The reason for the slightness of any injurious effect on the kidneys must be sought in the great influence of ascents upon the circulation, especially the increased arterial fulness with compensatory lowering of the vascular tone, whereby the venous pressure must be diminished and the venous circulation be quickened.

The persons suffering from morbid changes in the circulation disposing to albuminuria, but not causing it on this occasion were—

1. A man, aged 38, with slight cardiac hypertrophy; ten hours' exertion.

2. A woman, aged 23, with obesity and fatty heart; nine hours' exertion.

3. A man, aged 40, with neurosis of the vagus; six hours' exertion.

4. A man, aged 58, with scoliosis of the upper dorsal vertebræ; eight hours' exertion.

No albuminuria was found in any of these persons after the above mountain-ascents, which required great effort on their part.

On the other hand, an increase of albumen was found in the urine of a patient suffering from Bright's disease after an ascent of 896 metres above the valley-level, though the use of raw eggs had not increased it (see p. 104). But the albumen diminished during the next few days even below the usual quantity—viz. quite the half. Unlike the case recently considered, the excretion here took place both from the glomeruli and the tubules, though the greatest share in the diminished excretion during the next few days must be set down to the glomeruli; and this last fact shows that mountain-ascents have no injurious influence.

In the investigations on this point conducted by Dr. N. in 1875, only a relative increase of the existing albuminuria was observed, since, owing to the great watery loss from the skin and lungs, the urine was reduced in quantity, and thus only a slight increase of the percentage of albumen was obtained.

Setting against our presupposed injurious influence the possibly favourable influence of mountain-ascents, we may expect on the one hand—to return to our case of a deranged circulation

—*an equalisation of pressure*, an elevation of the arterial and a lowering of the venous pressure; on the other hand we have also the *increased volume of arterial blood*, and the greater amount of hæmoglobin carried to the kidneys, as well as the *increased quickness of flow*, from higher cardiac energy and easier outflow of venous blood. The nutrition of the renal epithelium, and therefore its secreting activity, would thus be restored to normal.

As regards mountain-ascents, then, and their influence on the kidneys, there are reasons for and against their practice, and those theoretical assumptions according to which albuminuria (or its increase) might be expected are not justified by facts. Where the disease has made such progress as the foregoing case shows in every particular, there is nothing more to be lost as regards the patients, and on grounds already stated we were unwilling to look upon the *immediate* result of the hill-climbing—viz. the increase of percentage albumen—as an argument for or against that exertion. We believed we could only judge of the influence upon the albuminuria from the subsequent consequences of a month's persistent influence of increased work and cardiac action, with a thorough reduction of the fluids of the body.

We have again, therefore, an experiment before us, the result of which we cannot determine beforehand.

SCHEME OF A MECHANICO-PHYSIOLOGICAL METHOD FOR THE TREATMENT OF CIRCULATORY DERANGEMENTS.

Having thus by experimental investigations established the method for the mechanical treatment of circulatory disorders, and having gained some idea of the manner in and extent to which we can correct them, whereby for the sake of clearness and on account of the peculiar development of this work much had to be anticipated, we come now to the attempt to practically carry out this method in the case given, and to follow up its influence on the physical aspects of the circulatory derangements and their secondary consequences.

The *method* is divided, as shown by the previous investigations, into two parts—

1. The *diminution* of the body-fluids, especially the blood, by removal of water ;

2. The mechanical correction of the circulatory disorders, and the strengthening of the heart-muscle.

When we pass on to their application we shall divide our measures into two parts accordingly.

The method was thus carried out on our patient :—

1. *As regards the diminution of the body-fluids* the first direction of all was to limit as closely as possible the amount of liquid imbibed, and to exercise a certain selection in the solids.

For breakfast the patient was allowed a small cup of coffee and some bread. The midday meal consisted of a small plate of soup (or it was omitted altogether), about $\frac{1}{4}$ kilo. ($\frac{1}{2}$ lb.) of meat (roast or boiled beef, veal, &c.), with some salad and vegetables, seldom fish, very little bread or starch-stuffs. As a drink at first a little beer or wine was allowed, viz. 100 to 150 c.cm. (about 4 oz.), but later on it was omitted entirely, a little fruit being taken instead. During the afternoon a small cup of coffee with a little water was allowed. In the evening a couple of eggs, some roast meat and salad, a little bread, and $\frac{1}{4}$ to $\frac{1}{3}$ of a flask of wine with a little water, were given. If distressing thirst or dryness of the mouth came on next day or during the night, the mouth was occasionally rinsed with cold water. In such cases a little fruit was allowed on going to bed, and on sultry nights $\frac{1}{8}$ litre ($4\frac{1}{2}$ oz.) of water was exceptionally permitted.

Fat and carbohydrates were permitted during the whole time, for reasons already given, but they were never taken in any large quantity. Thus, according to circumstances, lean roast pork or roast goose were not withheld ; and coffee was always taken with three to four parts of milk and a little sugar.

The average composition of the patients' meals for the first two months was as follows, and this arrangement was afterwards adhered to when the patient got accustomed to the restriction of water, with only slight modifications :—

Liquids	Quantity in grammes	Water contained in grms.	Solids	Quantity in grammes	Water contained in grammes	
					Maximum	Minimum
Morning:			Morning:			
Coffee .	112·5	105·0	Bread	70·0	24·9	24·9
Milk .	37·5	32·7	Midday:			
Afternoon:			Soup	0 to 100·0	—	84·7
Coffee .	100·0	93·3	Meat	200·0	113·0	113·0
Milk .	25·0	21·9	Green salad . .	50·0	—	47·1
Water .	25·0	25·0	Vegetables . . .	50·0	35·5	—
Evening:			Flour foods . .	100·0	—	45·0
Wine .	187·5	162·1	Bread . . .	25·0	—	7·0
Water .	50·0	50·0	Fruit	100·0	85·0	85·0
			Evening:			
			Two eggs, soft-boiled .	90·0	66·2	66·2
			Meat	150·0	87·0	87·0
			Cheese . . .	15·0	5·0	5·0
			Bread	25·0	7·0	7·0
			Fruit	100·0	85·0	85·0
Total .	537·5	490·0	Total . . .	975·0	508·6	572·2

Total of solids and liquids taken during 24 hours:—

Minimum, 998·6 grammes. Maximum, 1062·2 grammes.

The patient, whose weight at that time was 78·2 kilos. and the weight of whose blood (assumed to be one-thirteenth of the body-weight) was 6·015 kilos., thus drank as a maximum 0·538 litre of liquid in 24 hours, *i.e.* about one-twelfth the blood-volume, while his previous imbibitions had been on an average 4·325 kilos., *i.e.* about two-thirds the blood-volume.

The water which entered into his circulation in 24 hours lay between 0·998 kilo. as a minimum and 1·062 kilo. as a maximum, in striking contrast to his previous mode of living (see table, p. 17), where the water of the solids and liquids taken lay between 3·469 and 5·697 kilos., *i.e.* three to five times as much as the restricted quantity, and where of the liquids about seven to nine times as much was taken. There was, therefore, an unloading of the circulation to a corresponding extent.

Thus by this reduction of the fluids and partly of the solids only 0·998 to 1·062 kilo. of water was taken into the body. Now according to Voit's and Pettenkofer's investigations, 0·829 kilo. of water is daily given off by the skin and lungs during

rest and fasting, and according to my own investigations with restricted water-supply and during rest 0·763 kilo. is given off. But, as we have seen, this quantity can be much increased by exercise, the Turkish or vapour bath, pilocarpine injections, and especially by ascents of elevations, viz. from 31·8 grms. per hour to 256·3 grms. per hour, or 1·474 kilo. during 5¾ hours' ascent.

The water-excretion at these times exceeds the water-supply by 0·476 to 0·412 kilo., and therefore the increased excretion, on the one hand from the skin and lungs, on the other from the kidneys, *could only be derived from the blood and the tissues generally.* Hence we may safely say that by this remarkable diminution of the fluid supply, hardly enough being given for the necessary tissue changes, a rapid progressive loss of water from the blood and tissues must occur.

Finally, to this part of our problem belongs the means by which we may sufficiently increase the water-excretion from the skin and lungs. In order to act at once upon the lungs, heart, and skin, the corresponding disorders being so intimately connected, I selected, for reasons already stated, *arduous walking exercises* as my means for inducing increased watery loss from the skin, and especially mountain-ascents, as the kind of walking which acts most quickly on the skin. The patient was to walk a great deal, and to ascend considerable elevations according to his strength, going slowly and stopping every ten or fifteen minutes whenever the heart's action became violent and the breathing laboured. He was to make several deep inspirations till the cardiac palpitations should be allayed, and then to resume his journey. The time of the exercise was not to be less than an hour and a half at first, and was to last two hours after a few ascents were made, so that heights of from one hundred to three hundred metres would be ascended.

The perspiration would, according to the foregoing observations, be very profuse, but besides this a good deal of water would be lost from the lungs, owing to the forced respiration, and hence there would be a rapid removal of water from the body.

As to the other methods of removing water, I thought I might dispense with them in this case, since this one method thoroughly carried out seemed likely to remove as much as I

thought necessary for diminishing the blood-volume and adapting it to the circulatory condition.

2. *The mechanical correction of the circulatory disorder and the strengthening of the cardiac muscle* followed from the above measures, or rather were facilitated by every means conducing to a balance between the blood-volumes in the arterial and venous apparatus respectively, and to a *strengthening of the heart-muscle, i.e.* to a *restoration of the previous compensatory hypertrophy.* Accordingly, the direct results which here interest us are given in the patient's history, which will now be taken up again.

Practical Application of the Method.

Continuation of the preceding Clinical History.

In order to carry out the method above projected, the patient in August 1875 went first to Tegernsee, and then from September 2 to 16 to the mountains of the Tyrol.

His mode of life, the supply of solid and fluid nourishment, during these six weeks remained pretty uniform, and the work done, the bodily effort of the fatiguing expeditions, was fairly distributed over this time.

On the first and second days after arriving at Tegernsee, short walks on level ground were taken before and after dinner. Even on level ground the dyspnœa and palpitation compelled the patient to stop every eighteen or twenty steps, and up-hill every eight or ten steps. As the slightest exertion at that time caused profuse sweating, its amount even in these small expeditions under an August sun was very great. The urine passed during the night at this time deposited a copious sediment of urates, and still more so later on, the loss of water from the skin being insufficiently replaced. The quantity was between 200 and 300 c.cm.

On the third day, the ascent of the Riederstein was undertaken (height above the sea 889, above the valley 157 metres). This was a most laborious undertaking, and Dr. N. had to stand and rest every eight, ten, or twelve steps wherever the road was steep, and even on level ground every twenty steps at most. The perspiration was profuse from the very first, the cardiac action frequent and strong, especially after ascending a little way, and the breathing quick and deep, especially during the resting pauses, when the want of breath

was extreme and respiration was conducted with deep, forced inspirations, the respiratory muscles contracting almost convulsively, and the thorax visibly rising and sinking. It is quite impossible to make at will respirations so rapid and strong, the thorax being dilated to the utmost possible extent and the heart acting powerfully, and to maintain them with such intensity as is the case in a mountain ascent of this kind. The time occupied in this ascent was about three hours and a half; the descent took three hours. The ordinary time of ascent for healthy people is one hour. The loss of water, owing to the copious sweating and increased respiration, was extremely great. The mouth and throat felt dry; the saliva was lessened, viscid, and bitter like brine. But the patient felt no particular exhaustion when the ascent was over, neither was there any cardiac palpitation or irregularity afterwards. No food was taken during the ascent or descent, but a light meal was taken on the Lehberg. This consisted of a little soup, a quarter of a litre of wine, two eggs, and a little bread and ham. The afternoon coffee was missing this day; the evening meal took place at Tegernsee as usual. During the night about 200 c.cm. of urine were passed, which deposited much urates.

On the remaining days of the first week easy walks were taken to neighbouring places of interest—Westerhof, Pflügelhof—or to the nearest villages. The influence of these expeditions on the water-excretion, respiration, and cardiac action corresponded with the degree of exertion.

In the *second week* the Neureut was ascended (height above sea 1,259, above the valley 527 metres). The ascent took four hours (the usual time is two hours), and the descent three. The ascent was very similar to the above, and, owing to the elevation, the patient had to stop from 130 to 150 times, in order to take the necessary quantity of air into his lungs. Corresponding to the long and arduous ascent, the heart's action was rapid and strong, occasionally violent, but it was never irregular at any time. There was a good deal of perspiration at starting, and after a little while it quite poured from the surface, saturating the clothes. On arriving at the summit and resting a minute or two, he felt no particular exhaustion, but resumed his journey in his own way, feeling fresh and strong. Even later on, after the descent, he did not feel very tired, and the soreness and stiffness of the muscles of the thigh and calf after the unwonted exercise were not at all severe. Here too, as after the previous mountain ascent, no unusual irregularity of pulse or palpitation occurred during the night or the next day; but he was

tormented by thirst, and it required a strong effort of his will to restrict himself to the permitted quantity of fluid. The sultry summer nights made the thirst still more annoying, and it was only allayed somewhat by frequent rinsings of the mouth with cold water.

For the next few days and during the third week bad weather prevented all exercise beyond short walks. Small elevations were ascended in the fore- and after-noons, and a gentle promenade to the lake was made in the evenings.

In the *fourth week* the patient undertook an expedition to the Rottacher waterfall, and ascended most of the heights of the Bodenbach fall. On this occasion for the first time he noticed a distinct lessening of his circulatory and respiratory troubles. The road to the waterfall, almost all level for an hour and a half, was very easily walked, and whereas previously he had been obliged to stop every twenty steps, or twenty-five at most, he could now take sixty, eighty, and even a hundred steps before dyspnœa and palpitation set in. While ascending the Bodenbach fall he was able to mount to two or three times the old height before being obliged to stop and rest. The expedition was as trying as the previous one, and had the same influence upon the water-excretion, respiration, and circulation. But in the short excursions of the next few days the signs of improvement became more distinct, and distances which had previously compelled him to halt were now passed over without trouble.

From Tegernsee the patient betook himself to Tyrol, where his diet and exercise were still regulated on the same principles.

The first severe undertaking here was a walk to the Ebnerkapelle, in Kitzbühel, which is situated on a mountain an hour's distance from the town. The road, which was pretty steep, was fairly well walked by the patient; the interruptions of the ascent were fewer than usual, and the 'Kapelle' was reached without any weariness in an hour and a half. The return journey afforded no difficulty, and was completed in a little over an hour. The next few walks took place in the vicinity of the town, being limited to level ground, owing to bad weather. They caused no special respiratory embarrassment, but there was always much sweating.

The second long excursion in the Tyrol, on which occasion a striking improvement in every respect was observed, embraced Ferleiten (1,147 metres above the sea), and the ascent of Trauneralp (1,521 metres above the sea, 374 above the valley). The journey from Bruck to Ferleiten was made by carriage, and Dr. N. afterwards walked for an hour in the Ferleiten valley at a much quicker rate than formerly, and with fewer halts. Next day he went back

to Thalschluss, a journey of about an hour and a half, in two hours, and made the ascent of the Trauernalp in about three-quarters of an hour. While the road along the valley was as easily walked as before, the sharp ascent of the mountain gave more difficulty, and the increased need of oxygen for carrying on the muscular work was felt the more owing to his small vital capacity. He was often obliged to stop; the breathing was quickened and audible at a distance, and deep; forced inspirations ensued on every halt. The heart's action was rapid and even violent, with a powerful impulse, but the separate phases—the increase and decrease in the intensity and number of the contractions—were regular. Perspiration was active, and much water was lost from the skin. On gaining the summit he felt fresh and comfortable; the breathing was free, and the pulse quiet, strong, and regular. The descent was made without any stoppage in about an hour and three-quarters. After his usual dinner he went on to Fusch in about two hours without any great effort or weariness, and owing to the road being downhill all the way, with few interruptions. From Fusch to Bruck the carriage was again used, and the night was passed in the latter place. Next day Herr N. returned to Munich *viâ* Salzburg.

Further Results.

If the improvement witnessed during the patient's mountain tour was striking, it became still more manifest on his return home. Dr. N. was now no longer obliged to stand still in walking the streets, where formerly he used to stop fifteen or twenty times during a walk; and whereas previously he had to go very slowly if he wished to get along at all, he could now walk as well as ever he did, and could even converse easily with a friend while walking without losing his breath. Two or even three flights of stairs could be mounted without halting, and there was only a quickened respiration or slight palpitation for a few seconds if the stairs were very steep or were quickly ascended. The pulse, too, had lost its occasional irregularity, and was stronger and fuller. The palpitations which used to occur during rest in bed, and often even waked him out of sleep, had now entirely ceased, and only occasionally a strong beat or two of the heart reminded him of them. There was no longer any doubt that, on the one hand, by the restricted fluid supply and enormously increased loss of water, on the other, by the influence of locomotion on the blood-distribution, a balance had been gradually effected between the arterial and venous apparatus; and that, through the powerful gymnastic of the heart-muscle which occurred under

the effort of mountain-climbing, the previous compensation was now re-established. Finally, the patient noticed a decided decrease of his obesity. The subcutaneous fat was everywhere much diminished, and the body had become thinner without suffering at all in muscular strength. His girth had fallen from 128 to 116 cm. (50 to 45·5 inches), and his weight from 78·2 to 69·25 kilos. (172 to 152·35 lbs.)—*i.e.* he had lost 8·95 kilos. (19·7 lbs.)

Conclusion of Clinical History.

The progress of the case to the present time is as follows :—

Favourable as were the alterations in the circulation, the stasis had not been altogether compensated, and it was not to be expected (especially so long as the œdema of the feet continued, indicating no slight difference of pressure in the vessels, with alterations of their walls) that it would from henceforth subside of itself, and not rather be increased again under an imperfect regulation of the supply and excretion of liquids.

On these necessary assumptions, I have regulated his food and drink for the past eight years in the following manner, not differing essentially from the earlier *régime* :—

For breakfast the patient took a cup of coffee and two small breakfast buns; nothing was taken in the forenoon. The midday meal, taken at 1 P.M., consisted of a small plate of soup, a good slice of roast or boiled meat, and some green vegetables or salad, with little or no bread. Rarely there was a second course of meat or a little farinaceous food. Fruit replaced liquids entirely at midday, according to the season, $\frac{1}{8}$ to $\frac{1}{6}$ kilo. of cherries (about $\frac{1}{4}$ lb.), or one or two pears or apples, or some grapes. Between 5 and 7 P.M. a cup of coffee was taken with milk and a little water. The evening meal consisted regularly of two soft-boiled eggs, sufficient meat, and some cheese, preceded by a little caviare or salt fish; the drink was $\frac{1}{4}$ litre of wine with or without $\frac{1}{8}$ litre of water. The amount of fluids taken in 24 hours was scarcely more than 550 grammes (a little over a pint), to which we must add the small quantity of water contained in the solid food. This *régime* was acquiesced in the more readily inasmuch as the feeling of thirst gradually subsided, and the small quantity of fluids taken amply sufficed for tissue-change and for the excretion of the urinary salts.

As regards exercise and increase of perspiration, Dr. N. had plenty of walking, with occasional ascents of stairs, in the performance of his professional duties. Every spring and autumn, by a two and six weeks' residence respectively in a mountainous neighbourhood, he regularly undertook some trying walks and ascents, restrict-

ing himself to the same quantity of liquid as on the first occasion. A great reduction always took place at these times in the gradually accumulated fluids of the body, owing to the great increase of fluid excretion by the skin and lungs and the very small fluid supply. These small expeditions cannot be further described, owing to their number; suffice it to say that, every day the weather permitted, a journey of two or three hours was taken. The following were the more important expeditions taken during these years:—

No.	Year	Mountain	Height above sea in metres	Height above valley in metres	Time of ascent in hours	Usual time of ascent	Difference	Time of descent
1	1875	Riedererstein . . .	889	157	3½	1	2½	3
2		Neureut	1,259	527	4	2	2	3
3	1876	Pfänder, near Bregenz .	1,070	672	3	1½	1½	2
4		Jägerkamp . . .	1,743	957	4	3	1	2½
5		Stilfser Jochstrasse, near Ortler	2,756	1,208	5	4	1	—
6	1877	Bodenschneid, through the Duftthal . . .	1,682	896	4	4	0	2½
7		Brecherspitze . . .	1,687	901	3½	3	½	2½
8		Rothwand, over Spitzing and Schwarzkopf .	1,890	1,104	4½	4–4½	0	3¼
9		Bodenschneid . . .	1,682	896	3	3	0	2
10	1878	Bodenschneid . . .	1,682	896	3	3	0	2
11		Bodenschneid, Suttenkopf, Stümpfling, Stümpflingwand, Grünseeeck, Haushammeralm, Spitzing—Neuhaus . .	1,682	896	9	8–9	0	—
12		Jägerkamp . . .	1,743	957	3½	3	½	2
13		Rothwand (descent to Geitau) . . .	1,890	1,104	4½	4–4½	0	3
14		Wendelstein, from Bayerischzell (road very bad)	1,849	1,063	3¾	3½	¼	2¼
15		Schynige Platte (Bernese Oberland) . . .	2,070	1,502	4	4–4½	0	2
16		Lower Grindelwald Glacier on the Zäsenberg	1,852	795	4–4½	4	0	3

Moreover, long walks were taken in the Bregenzerwald and Appenzellerland, and in the succeeding years similar tours amongst the Bavarian and Tyrolese mountains.

On glancing at the expeditions undertaken in 1875–78, and comparing the corresponding action of the circulation and respiration with the earlier condition, the difference is very striking. The patient, who previously could scarcely take twenty steps on level ground without having to stand still from dyspnœa and palpitation,

was now able to ascend elevations of over 1,500 metres (about 5,000 feet) above the valley-level, without hindrance either from the respiration or the circulation. Most of these journeys, especially Nos. 11, 13, 14, and some later ones, demanded a strength and endurance in going uphill only possible with a perfect capacity of the organs of respiration and circulation. He was on some occasions ten or twelve hours on the road and ascended 1,500 metres. He was quite able to keep up with the Bavarian or Swiss guides on level ground, and only up steep ascents was he obliged, in consequence of his small vital capacity and the increased flow of blood to the right heart, to halt somewhat oftener, so that the guides often went before him, however well he went in the intervals. After each expedition was over, Herr N. felt no exhaustion and passed an excellent night. There was no palpitation or irregularity of the pulse, and next day he felt quite fresh, the breathing was free, the inspirations were slow and deep, the expansion of the thorax was ample, the pulse tranquil, strong, and regular, the limbs were fresh and supple, and the cramps which used to occur at first after unwonted climbing were now entirely absent.

According to these observations we are compelled to assume that the previous circulatory derangement, which had been of so threatening a character, and which years ago had caused the late Professor Lindwurm to give a very grave prognosis, may now be regarded as quite done away with, and that the physical conditions on which the respiratory and circulatory mechanisms depend are perfectly restored.

It remains to investigate to what extent the pathological changes already existing in the *different organs* are amenable to and capable of retrogression, with the reduction of the blood and the removal of the venous stasis, under the influence of mountain-exercise; how we must look upon and realise these alterations; and, finally, with regard to the permanent condition in the case before us, how the general health of the patient has been affected during the last eight years, and what resistance his body now opposes to injurious influences from without.

Alterations in the Diseased Organs under the Influence of the Treatment.

The first organ to which we must give our attention is—

1. *The Heart, with the Vascular Apparatus and the Circulation generally.*

The restoration of the previous compensations, with increased functional capacity of the heart, has already been shown

in the general description of the treatment and the course of the disease. It is only to be added that the results obtained so far (1884), *i.e.* within a period of nine years, have been constant, and indeed there has been a steady improvement every year.

Spontaneous irregular cardiac action, palpitations, feelings of oppression, irregular and jerky pulse ceased to occur again. The rhythm of the heart's action was perfectly regular, slow, and only slightly quickened, even by rapid walking on level ground. Palpitations only occurred during long or steep ascents, and they never reached the violent palpitation that previously inevitably followed the ascent of a few steps upstairs. Even in long and steep ascents there was never that sense of oppression in the neighbourhood of the manubrium sterni and of both infra-clavicular regions from engorgement of the right heart and great venous trunks, that feeling of distress as if the breast would burst, nor that pressure on the bladder and rectum, such as used to occur on the ascent of three ordinary flights of stairs.

With these regular and energetic cardiac contractions were connected a more uniform distribution in the circulatory apparatus and increased filling of the arterial system.

The pulse, once very frequent, 112 to 120 per minute, or sinking to 54 or even 48, irregular, jerky, and small, was now rhythmical, slow, regular (80 to 84 per minute), full, powerful, and not easily compressed.

These alterations appear plainest in the pulse-curves, as the sphygmographic tracings showed them, and still show. I am sorry I do not possess any tracing taken in the early period of the case, though many were taken then by the patient. But quite recently I have obtained tracings from a patient in whom circulatory disturbances appeared in consequence of valvular sclerosis and failure of compensation, and these pulse-curves resemble those then taken from our patient so closely, that if put side by side they could not have been distinguished without special attention. We have therefore in these pulse-curves a perfect picture of the alterations then existing in the pulse of the patient (fig. 36).

The pulse is small, irregular, and jerky. After many insig-

nificant irregular elevations, or a greater interruption, the ascent of the primary wave begins sharply, but is followed at once by decline of the heart's force and imperfect contraction.

Fig. 36.

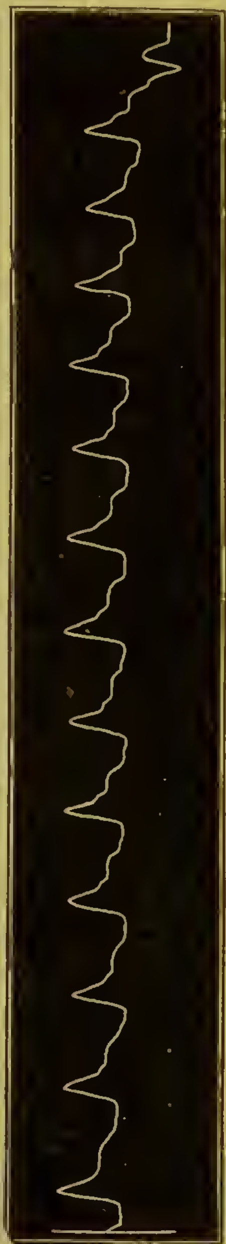


Fig. 37.

No elevation resembles another. The heart-muscle is perfectly insufficient, and the pulse-curve distinctly shows the efforts which it makes to overcome the stagnation of the blood. Small imperfect waves are formed, a curve now and then shows distinct anacrotism, or the dicrotic elevation is raised to the summit; and at different places there appear elasticity-waves, while other waves are hardly marked by any distinct elevation, or the pulse-curve is even quite absent.

By regulation of the fluid supply and strengthening the heart-muscle, a pulse-curve is gradually developed from this, which only varies slightly from the normal, and in which for the most part the aortic pressure again comes into view, increased by the restored compensatory cardiac hypertrophy (fig. 37).

The ascending limbs are pretty steep, of uniform height, or nearly so, and pass by an acute angle into the descending limbs. About 2 or $2\frac{1}{2}$ mm. below the summit each curve shows the valve-closure wave quite distinctly; the dicrotic

elevation is a little lower, and one or two little elastic waves end the curve. In some pulses (compare fig. 4) the valve-closure wave is nearer the summit, or may follow it immediately. This is due to cardiac hypertrophy and higher arterial pressure.

The decided alterations which occurred in the patient's circulation cannot be better expressed than by these curves. They directly show also the compensation and cardiac hypertrophy known to exist by other means, and by the patient's subjective feelings for years. In the years 1869 to 1875, when the circulatory disturbances gradually increased and attained their acme, no useful instrument existed for obtaining the blood-pressure in man with sufficient accuracy. The sphygmomanometer of Basch first enabled us to do this, and, besides giving the variations of pressure in the same individual, to determine the deviations from the normal.

Von Basch [1] found after numerous measurements that strong healthy men of middle age show a blood-pressure of 120 to 150 mm. Hg. He indicates such a pressure as normal, a pressure under 120 mm. as weak, and a pressure above 150 mm. as strong. Christeller [2] observed in patients with badly compensated heart failure a lowered pressure of 70 to 100 mm. Hg; but where the compensation was good the blood-pressure was 120 or 130 mm. Hg. Although these measurements give no absolute values, they serve as starting points for estimating variations of pressure in such circulatory disturbances.

By repeated measurements taken at different times, the blood-pressure of the patient varied between 123 and 135 mm. Hg, and these figures show the perfectly restored strength of the heart by compensatory cardiac hypertrophy.

The increased power of the heart and of other muscles that follows prolonged hill-climbing is best seen by a comparison of the time of ascent of the Spitzinghöhe in 1883.

Between these different ascents there occurred six long and often arduous mountain expeditions, and a number of long walks,

[1] V. Basch, 'Ueber die Leistungsfähigkeit des Herzens bei dessen Functionsstörung,' *Verhandl. des II. Congresses für innere Medicin*, 1883, p. 296.

[2] P. Christeller, 'Ueber Blutdrucksmessungen beim Menschen unter pathologischen Verhältnissen,' *Zeitschr. f. klin. Med.*, vol. iii. part i.

by which especially all those influences were brought to bear which our investigations have shown to be most powerful in strengthening the heart.

Date and No. 1883	Blood-pressure in mm. Hg					Pulse-frequency on the Spitzinghöhe	Time of ascent in min.	Number of halts	Cardiac palpitation	Difficulty of breathing
	At home	On the Spitzinghöhe	Increase	Neuhaus	Increase					
I. Aug. 7	135	178	43	178	40	136	60	5	much	slight
II. „ 18	132	144	12	138	16	124	50	3	slight	slight
III. Sept. 4	125	136	11	130	5	124	45	2	noticeable	—
IV. „ 11	125	129	1	124·8	−0·2	120	40	—	—	—

On his first ascent or two after an interval of some months, the patient felt severe palpitations at the first steep part of the journey, which recurred on going quickly; they gradually declined in the following trials after hills of 2,900 and 3,600 feet above the valley had been ascended, and disappeared altogether in the fourth ascent. Again, the halts that had to be made, partly from palpitation, partly from dyspnœa, were lessened from five to three, then two, and the last ascent was uninterrupted, being effected with no greater effort than the same distance on level ground would have required. The time expended is in exact accordance with the other changes. The average time for pedestrians is considered to be one hour,[1] and this time was taken in the first of the above ascents; the next took 50, the third 45 minutes. and the last, a quick and uninterrupted ascent, took only 40 minutes.

Since the weaker the heart-muscle the more quickly it is thrown into violent action and palpitation, and the stronger it is the more quietly it does its work, so, the work being the same, we can only explain the absence of palpitation by the increased vigour of the heart-muscle, which with strong uniform contractions drives into the aortic system the increased quantity of blood coming from the lungs.

The absence of all respiratory trouble indicates a greater flow of arterial blood from the lungs to the left heart, and an excess of oxidised blood in the muscles, now expending more force.

[1] Trautwein, *Südbayern*, 1882, p. 95.

We have already mentioned and shown the decrease of pressure in the above experiments (see p. 163).

The increased strength of the heart and its enlargement followed upon the method chosen, just as increase in strength and size occurs in other muscles by gymnastics and increased supply of nutritive material.

As the arteries of the body persistently dilate when there is increased muscular action (especially hill-climbing), as we have shown by measurements of the blood-pressure, and by determinations of the size and tension of arteries, so the coronary arteries enlarge proportionately, and carry a greater supply of oxygenated blood to the muscular tissue of the heart.

We can therefore correctly speak of a 'gymnastic' of the heart-muscle in hill-climbing, and this is especially shown when we are dealing with weak conditions of the heart, as in anæmia (chlorosis), atrophy, and fatty heart.

Finally, as to the blood-distribution, the gradual removal of the pigmentation of the skin and mucous membranes is to be noticed, the decided cyanosis disappearing and giving place to a colour of normal redness. The severe perspirations also, which used to be caused by the slightest effort, diminished in an extraordinary manner, and even severe walks and ascents did not provoke them more in the patient than in the healthy persons accompanying him.

On percussion I thought I obtained a slight diminution of cardiac dulness, but, considering the shape of the patient's thorax and the condition already described, I could not put any great value on this, since, although the volume of the heart was lessened by absorption of the deposited fat, this would be neutralised by the compensatory hypertrophy of its muscular tissue.

2. *The Lungs.*

The symptoms belonging to the lungs and the rest of the respiratory apparatus underwent alterations in equal degree with those of the circulatory disturbances, and these alterations were most unmistakably expressed both subjectively and objectively.

The respiration was easy both during rest and movement;

the separate automatically conducted respiratory acts increased steadily in depth and regularity without any coughing or wheezy noises (which the inspiratory and expiratory current of air causes by too sudden expansion of the thorax). Even on walking fast the rhythm of the separate respirations was regular and slow, and was only quickened by the rapid ascent of steep places, mountain crests, when the simultaneous bodily efforts caused a greater need of breath. In such cases the difference between the pulmonary space of the patient and that of his companions most plainly appeared by a smaller vital capacity, his frequency of breathing compared with theirs being as two to one, or three to two. The breathing was then very audible, but never strikingly so, and was quite unnoticed by any companions present, amongst whom one or another was sure to be rather short-winded, owing to corpulency or other causes. It happened not seldom that on such occasions the easier respiration of the patient quite surprised them. Speaking also during the walk or even in the ascent no longer troubled the respiration, at least no more than with other people under the same circumstances. In particular, speaking long sentences in company, or even discoursing for an hour or more, was no longer accompanied either by want of breath or other respiratory trouble.

Other influences on the respiratory organs, especially those lessening the respiratory space, did not affect the respiration in any way and were quite disregarded by the patient. Stooping, especially when connected with sudden compression of the thorax and abdomen, used to provoke temporary dyspnœa at once, so that the patient avoided it, or did it slowly and carefully, usually bending one knee. This and similar movements were now performed as simple mechanical acts, without attention or discomfort. Taking a meal also, the filling of the stomach, and its consequent pressure upwards against the diaphragm and the partial diminution of the thoracic space, gave no trouble to the breathing, as used to be the case regularly; nor was walking or going upstairs after a meal, which formerly entailed the greatest trouble and effort, of any influence at all. Like the abdominal pressure, the patient now bore easily a greater or less external pressure compressing the thorax, such as lifting or carrying heavy objects, whereas formerly the weight

of an open umbrella or an overcoat was unbearable, and avoided by him as much as possible.

Finally, a strong wind or a storm taking the patient by surprise on a walk used to have an extraordinarily bad influence on the respiration, causing severe dyspnœa or almost stopping the breath, and compelling him to seek protection in any way possible. This influence is no longer felt, and when surprised on his expeditions by a blowing wind he is scarcely more affected than his companions.

As to the physical investigation, the inspiratory enlargement of the thorax measured across the nipples had increased $1\frac{1}{2}$ to 2 cm. ($\frac{1}{2}$ to $\frac{3}{4}$ in.), and the vital capacity from 1,050 c.cm. to 1,300 or 1,350 c.cm. (from 64 cub. ins. to 83·2 or 86·4 cub. ins.) The degree of alteration that had taken place in the respiratory process is hardly sufficiently expressed in the above small figures in comparison with the normal amounts, but must be deduced rather from the above-mentioned circulatory alterations, the reduction of the blood-volume, and the perfect restoration of the previous compensation.

3. *The Bronchial Tubes.*

The therapeutic consequences as to the bronchial tubes and the rest of the respiratory tract afford special interest.

With the advancing development of the circulatory disturbances a marked predisposition to bronchial and laryngeal catarrhs had set in. These were attended with severe cough, profuse secretion of mucus, and shortness of breath, which often went on to persistent and alarming attacks of dyspnœa. In autumn chiefly, when the patient had to expose himself to the commencing rough weather, less often in spring, catarrhs were easily provoked, which used to prove most rebellious against treatment. With the subsidence of the circulatory disturbances in the winter of 1875–76 these laryngeal and bronchial catarrhs *ceased to appear*, and, as ten or fifteen years ago, so now the patient could bear the most intense cold, and the sudden changes of temperature between that of his chamber and the outer air repeated forty or fifty times a day, besides the tran-

sitions from autumn to winter and from winter to spring, without suffering from any catarrh of the respiratory mucous membrane worth naming. In the winter of 1879–80 the difference in temperature between his chamber and the outer air was sometimes as much as 40° C. (72° F.), and, though professionally much engaged, his respiratory organs never suffered.

These remarkable facts can only be explained by the circulatory alterations. Previously, the very extensive general venous stasis had caused extreme venous hyperæmia and stasis in the respiratory mucous membrane, which again had led to serous infiltration and swelling of the mucous and submucous tissues, and had maintained a condition readily reacting to slight injurious influences, *e.g.* sudden changes of temperature, chills, &c., with severe catarrhal symptoms and profuse transudation into the tissues. By the thorough reduction of the blood-volume, and the consequent balance in the circulatory apparatus, the excess of venous blood and its stagnation in the respiratory mucous membrane disappeared, and the swelling and serous infiltration of the latter apparently vanished *directly* after the increased excretion of water by the skin and lungs and the extremely reduced supply of water. This appears the more probable if we remember the great thirst and dryness of the air passages, as far as subjective sensations went, which followed the first trying expeditions (see page 191).

The complete eradication of the catarrhal predisposition from the larynx and bronchi stands then in the closest connection with the dehydration of the body, and was such as to leave the patient insensitive to shocks from the weather and differences of temperature. The catarrhs ceased to appear, which used to afford the most obstinate opposition to treatment, and always took a long, insidious course with a series of troublesome symptoms. These facts are of the greatest importance as well for the etiology as the treatment of such affections. Inasmuch as these catarrhs have their origin in the venous hyperæmia and serous infiltration of the mucous membranes, their treatment by ‘drink cures’ of Emser, Weilbacher, and other waters, which increase the fluids of the body, must be regarded as a failure—easily incurred, however, owing to the chronic course of such catarrhs and the often troublesome expectoration.

The treatment of catarrhal affections resting on such a basis will henceforward be conducted on the principles resulting self-evidently from the above facts. On looking back at this history we find we possess a means, not only of curing existing diseases of the bronchial mucous membrane, but of removing any further disposition thereto. In the last few years I have repeatedly had occasion to observe such catarrhs resting on hyperæmia due to stasis, and to treat them successfully in a similar way. I shall return to this point later on.

4. *The Kidneys.—Dropsy.*

The first influence which the treatment exercised on the kidneys and their functions was caused on the one hand by the increased water-excretion by the skin and lungs, and on the other by the reduction of the fluid supply, and expressed itself in the unloading of the kidneys.

The freshly voided urine was very dark and scanty, and deposited on cooling a large quantity of urates. Its amount was between 500 and 600 c.cm. in twenty-four hours. Exact determinations could not be made, especially on the days of mountain expeditions connected with copious perspirations; and from various causes they were omitted. Later on, when the vicarious cutaneous and pulmonary transudations lessened in amount, and the supply of water was again somewhat larger, the quantity of urine became correspondingly increased. Moreover, at that time and in the following year these quantitative variations still existed, which used to form a regular symptom. Sometimes 500 to 600 c.cm. (about Oj.), sometimes 800 to 1,000 c.cm. (28 to 35 oz.) of urine were passed, the larger quantities being remarkably pale and very frothy. In each kind of urine, the watery and the more saturated, albumen was often found in varying quantities; quantitative estimations were not made. The last traces of albumen disappeared six years ago, while the symptoms of stasis had disappeared already by the autumn of 1875. It deserves notice, moreover, that excesses in the amount of fluid fixed upon for the patient, if they lasted several days or weeks, were followed by the

above-mentioned variations in the quantity passed, up to the last four years.

With the advancing regulation of the urinary excretion the peculiar dragging sensation in the hypochondria and lumbar regions was perceived less often, but was always felt twelve to twenty-four hours before the passing of large quantities of clear watery urine, so that the patient had his attention drawn to these secretory disturbances; while at the time when the pressure came on in the loins, and often a little while beforehand, only a scanty and highly saturated urine was passed.

But the other symptoms, caused by the extensive venous stasis, and the participation of the kidneys in the circulatory disturbances gradually retrograded, though more slowly than the above described. The rust-coloured pigmentation on the lower limbs, especially along the shins, extended no further, nor did fresh spots appear in their neighbourhood or on the dorsum of the foot or the malleoli. The disappearance of these patches was, however, extremely slow. The brownish rust-coloured places only very gradually became paler, while smaller spots and spots less stained disappeared sooner. Up to four years ago the pigmentations along the tibia were present and gave evidence of a very protracted decolorisation.

Finally, it was *à priori* to be expected that with the subsidence of the venous stasis the œdematous swelling on the dorsum of each foot would disappear. The appearance of watery fluid in the subcutaneous tissues (especially of the lower extremities) is induced, however, not merely by the excessive pressure of the columns of blood in the veins upon their walls, but by the nutritive disturbance also which the vascular wall has suffered from the watery blood, long altered considerably in its composition. Many months passed by; the other subjective and objective symptoms of circulatory disturbance all disappeared, and a perfect compensation was introduced, before any noticeable alteration was observed in the œdema. A distinct lessening was only seen two years afterwards, and this progressed with extreme slowness and occasional long interruptions. The last traces disappeared altogether in the winter of 1877–8, *i.e.* more than two years after the fluids of the body had under-

gone the necessary reduction, and the cardiac and pulmonary symptoms had ceased.

The varying œdema of the face, especially of the eyelids, disappeared before the above. With these latter symptoms the last traces of the previous serous transudations vanished, and the patient has felt perfectly well up to the present time. (On the alterations of the circulation in the kidneys, see page 177 *et seq.*)

5. *Reduction of Fat.*

The reduction in weight obtained under the influences of the methods employed has been already fully given in figures. Whilst before treatment the patient's circumference was 49·6 inches and his weight 171·6 lbs., these figures were lowered after a year's treatment to 37 inches and 116·6 lbs. The fat of the subcutaneous tissue was everywhere reduced to an insignificant layer, and the skin could be drawn in thin folds over the strongly developed muscles, which felt hard and firm on each contraction. Only over the abdomen there remained a rather thick layer of fat, and later on this also was reduced even below the average. Like the diminution of the body fluids, the fat-reduction was perfectly successful.

On the first projection of this method of treatment I had directed my attention less to the fat-reduction than to the neutralisation of the circulatory disturbances, and the fat-reduction has indirectly resulted from the solution of the latter problem rather than from any direct operation against the formation and accumulation of fat. The patient from his earliest youth did not care much for farinaceous food and disliked fat, however given. There was no need therefore to diminish the farinaceous and fatty food, but for reasons already given they were not directly avoided, and for the last few years have been taken more freely than before without tending to corpulency. Only the carbohydrates in beer were stopped altogether with its deprivation, and by increased muscular activity a great destruction of the non-nitrogenous constituents, both of the body and of the food, was induced.

We must seek for one cause, not to be left out of sight, of

the strikingly rapid diminution of the obesity, in the alteration of the circulatory derangements and the consequently increased oxidation (now again normal). While the blood had lost much of its water and was therefore thickened, it had become richer again in solid constituents, and especially in form-elements. The quantity of blood which streamed in a given unit of time through the pulmonary capillaries now held a larger quantity of blood-corpuscles, and the intake of oxygen was proportionately increased, or rather brought back to normal. In this relative increase of blood-corpuscles two factors—of extreme importance for the increase of the oxidation-processes—especially helped. (1) Owing to the increased quantity of blood, and especially the removal of the venous stagnation and the restoration of the previous compensation, a larger quantity of blood was brought to the aortic system, and the arterial pressure was raised to 125 or 130 millimetres of mercury. Through the regular and energetic contractions of the heart-muscle, the blood-flow became uniform, and its *rapidity* increased in corresponding proportion. *More blood absolutely* therefore passed through the pulmonary capillaries to be oxidised. (2) In consequence of the mechanical treatment of the lungs by the operation of long-continued forced inspirations, *the thorax underwent expansion* on every side; the alveoli, collapsed or insufficient from capillary ectasis or compression, were again distended by the pressure of the afferent air, and the respiratory surface itself was again increased. But, owing to parts of the lungs being again rendered efficient which were previously useless, and the re-exposure of their capillaries to atmospheric air, an increased supply of oxygen to the system was facilitated.

Collecting, then, the results of the whole methodic treatment in regard to the oxygen-supply, we have a relative and absolute increase of blood-corpuscles taking up oxygen from the inspired air, as well as an increase of the pulmonary surface where the blood comes into contact with the air. Through these fresh relations of the respiratory apparatus there was a decided increase of the supply of oxygen to the body, the dyspnœic troubles were overcome, and by the increased muscular work a general increase of the oxidation-processes occurred. These

two processes, the intake of oxygen and oxidation itself, did not overstep the physiological limit, but were simply brought back to the normal.

Finally, it became possible, from the rapid oxidation of the fat deposited in the body, that through the altered relation between the quantity of blood and the capacity of the vascular apparatus caused by the removal of water, *anæmia of the fatty tissue* might ensue, with obliteration of its capillaries, as we have endeavoured to explain, and that with a lower nutrition a much increased absorption of fat from the tissues would occur. If, therefore, increased oxidation were rendered necessary by increased work, and especially if the less easily disintegrated nitrogenous compounds were supplied to the blood in the food, the deposited fat would be oxidised, and used up more or less quickly according to the amount of tissue-change caused by work done. The very rapid fat-reduction of the patient must be therefore directly referred to these alterations in the respiratory and circulatory apparatus, and their accompanying influences. The tissue-change alterations due to the altered diet occupy only a second place.

During the last few years I have repeatedly had occasion to attempt the reduction of accumulated fat in organisms with extremely fatty hearts, on these necessary principles, and I have succeeded every time. The details will be found in the following clinical histories.

OTHER CASES SIMILARLY TREATED.

The great significance of the therapeutic task here for the first time fulfilled, in which propositions and results agree with almost mathematical accuracy, induces me to append a few other cases from the list given (see p. 13), which may be of interest from the variety of the remote causes of the circulatory disturbances, and from symptoms of other kinds.

Since in the preceding history I have tried to depict as clearly as possible the symptoms resulting from the circulatory troubles, and have everywhere developed the principles on which the treatment must rest, with a thorough discussion of the gradual restoration of the hydrostatic balance, and its

consequences both as to the separate organs and the whole organism, I am able to be so much the shorter in my reports of the following cases, because everything necessary for their explanation has been already said, and any particular differences may therefore be abbreviated.

Case II.—*Corpulency and fatty heart; commencing stasis.—Complete cure.*

A woman, aged 47. Has repeatedly sought advice on account of difficulty of breathing, feeling of anxiety, oppression at the heart, and palpitations. Intermittent catarrhs have only been overcome by depuration, and by suitable care on the part of the patient; they were often obstinate, especially in the winter months, and only disappeared completely on the occurrence of better weather.

The patient has gradually become very stout with advancing years, and especially since the menopause. There was considerable fatty deposition everywhere, especially on the arms, feet, breasts, and abdomen.

The countenance was somewhat livid and slightly cyanotic. The cardiac dulness reached beyond the right sternal border. The sounds of the heart were fairly audible, pure, and regular. Pulse small, empty between the beats, and pretty frequent, 88 to 92. The lungs, when no special catarrh was present, gave vesicular breathing everywhere. The urine was non-albuminous and varied in quantity, being clear or sedimentous accordingly. Commencing œdema on the feet.

As I believed the causes of the different symptoms complained of by the patient to depend on *venous stagnation*, caused by fatty heart and general obesity, I prescribed with a view to equalisation of the circulatory disturbances and a general fat-reduction. The fluid-supply was reduced to a minimum, on the above principle, so far as permissible for tissue-change and the excretion of urinary salts; fats and carbohydrates were avoided as far as possible in the diet, though not altogether, in order, together with strenuous muscular work and the intended increase of the watery excretions, to cause a rapid combustion of the body-fat. The following table represents the food and drink prescribed and taken every 24 hours by the patient :—

Amended Diet.

Fluids	Quantity in grammes	Water	Albumen	Fat	Carbo-hydrates	Analysis by
Morning:			(Thein)			
Tea . . .	130	127·3	0·50	—	0·83	König, partly
Milk . .	20	17·4	0·86	0·64	0·70	König
Sugar . .	5	0·1	0·02	—	4·80	,,
Midday:						
Wine (Austrian red wine)	100	87·8	0·10	—	3·00	,,
Evening:						
Wine (Austrian red wine)	250	216·3	0·21	—	7·50	,,
Water . .	250	250·0	—	—	—	,,
Total . .	755	698·9	1·69	0·64	16·83	

Solids	Quantity in grammes	Water	Albumen	Fat	Carbo-hydrates	Analysis by
Morning:						
Bread . .	50	14·0	4·8	0·4	30·00	Renk
Midday:						
Egg (soft-boiled)	45	33·1	5·6	5·4	0·24	König
Roast beef .	300	174·0	114·6	5·1	—	v. Voit
Green salad .	50	47·1	0·7	1·0	1·10	König, partly
Vegetables .	50	35·5	0·8	0·2	4·20	v. Voit
Bread . .	25	7·0	2·4	0·2	15·00	Renk
Evening:						
$\frac{1}{2}$ fowl, or veal, or steak, or game .	150	87·5	57·3	2·7	—	v. Voit
Egg . . .	45	33·1	5·6	5·4	0·24	König
Bread . .	25	7·0	2·4	0·2	15·00	Renk
Total . .	605	438·3	194·2	20·6	65·78	

Total in solids and fluids in 24 hours:—

Water . . .	1137·2 grammes (40·1 oz.)	Albumen . .	194·2 grammes (6·84 oz.)
Fat . . .	21·2 ,, ($\frac{3}{4}$ oz.)	Carbohydrates .	82·6 ,, (2·91 oz.)

The fluids taken were thus limited at the time to 750 grammes, containing 698·9 grammes of water, while the solids contained 438·3 grammes of water, making the total quantity of water taken daily 1137·2 grammes. By this arrangement about 2,000 to 2,500 grammes less water than before was introduced daily into the system.

Moreover in this case the large quantity of albumen taken is noticeable, which in its lowest figures exceeded the amount given by Banting by 23·9 grammes, and Ebstein's by 93·2 grammes, and was perfectly well borne by the patient. The fat given was 13 grammes more than Banting's, but 63·8 grammes less than Ebstein's amount; the carbohydrates were about the same as Banting's in amount, and exceeded Ebstein's by 35·6 grammes.

The exercise extended at first to daily walks in Munich and its neighbourhood, each walk lasting four to six hours, according to the weather. Later on, during a residence at Miesbach, she ascended the woody heights there and small hills (*e.g.* Stadelberg, 137 metres above the valley) repeatedly without any effort or stasis in the respiratory or circulatory apparatus. The time expended on these expeditions was, as usual in her walks, about four to six hours daily.

Under the influence of the altered diet, the lessened water-supply, and the increased muscular exertion, the body-weight underwent the following alterations:

On September 21, 1880, 90 kilos. On November 18, 1880, 79·5 kilos. Decrease = 10·5 kilos. (23 lbs.)

The repeated weighings between November 18 and October 20 gave the following:—

November	18, 1880,	79·5 kilos.		February	9, 1881,	69·5 kilos.	
,,	29 ,,	77·3	,,	,,	14 ,,	68·5	,,
December	3 ,,	76·7	,,	,,	27 ,,	69·25	,,
,,	17 ,,	74·25	,,	March	4 ,,	68·15	,,
,,	24 ,,	75	,,	,,	15 ,,	67·75	,,
,,	27 ,,	73·3	,,	April	19 ,,	67·5	,,
,,	31 ,,	72·5	,,	,,	21 ,,	66·5	,,
January	6, 1881,	73·5	,,	,,	29 ,,	67·75	,,
,,	11 ,,	72·5	,,	May	15 ,,	65	,,
,,	17 ,,	71·7	,,	June	2 ,,	64·3	,,
,,	24 ,,	70·5	,,	,,	6 ,,	63·7	,,
,,	31 ,,	69·7	,,	,,	17 ,,	63	,,

During a ten weeks' stay in Miesbach the patient's weight varied between 64·5 and 63 kilos.

In September and October we have the following weights :—

September	2, 1881,	64·1 kilos.		September	30, 1881,	63·5 kilos.	
,,	10 ,,	63·3	,,	October	10 ,,	63	,,
,,	13 ,,	62·3	,,	,,	20 ,,	62·3	,,
,,	19 ,,	62·1	,,				

Total loss of weight from September 21, 1880, to October 20, 1881 = 90 − 62·7 kilos. = 27·3 kilos. (= 60 lbs.)

This weight (62·5 to 63·5 kilos.) has been maintained by the patient to the present time—viz. the autumn of 1883—under a diet very little altered from the above; the fluid taken during the day being slightly increased to about 150 to 200 grammes of soup at midday, and 500 grammes of fluid (beer, wine and water, or water alone).

The old cardiac and pulmonary troubles, which existed for years, have wholly disappeared; the breathing is quite free; there is no oppression, no palpitation, no feeling of distress about the breast; the œdema of the ankles, the venous stagnation, and the cyanotic tint have all gone; and the general condition of the patient is perfectly normal.

Case III.—*Corpulency, with fatty heart and extensive venous stasis. —Rapid and decided fat-reduction and removal of circulatory disturbances under energetic dehydration.*

In this case, as in the last, there was a rapid diminution of the obesity under the energetic removal of water, and a diet which remained rich in fat and carbohydrates. The amount of muscular work done was not covered by the non-nitrogenous food supplied, plus the non-nitrogenous constituents of the body, and this was proved by the loss of weight.

The sudden and remarkable fat-absorption and fat-destruction in the body is to be regarded in part as the *effect of the removal of water*, as we have already explained.

J. W., aged 56, retired, formerly innkeeper and butcher, was always well nourished, and disposed to be corpulent. During the last few years, after retiring from business, his obesity has increased, and has become very troublesome to him. On account of movement being difficult he is quickly tired, and suffers from dyspnœa and palpitation on the least exertion, and this has led him to seek professional advice.

Present condition, November 27, 1879.—Medium size; strong, healthy appearance; weight 107·5 kilos. Appetite and action of bowels regular, lungs free, cardiac dulness not particularly enlarged, pulse 68–72.

The methods employed against his obesity were limited to a dietetic prescription, as, owing to the winter season, much outdoor exercise was out of the question, and for the sake of experiment I particularly wished to try the effect of the removal of water.

As regards the previous diet, some years previously large meals had been taken regularly, into which fat and carbohydrates entered largely, the latter both in the solids and liquids. But during the last few years, as his corpulency increased, he had broken them off on the advice of intelligent friends, and for the last eight or ten months had adhered to a diet almost the same as that in Table I. (see p. 216), without any other consequence than an increase of 1·7 kilo. in weight.

The diet which I prescribed had the composition given in Table II. As the tables show, the greatest reduction occurred in the supply of fluids. The 3,800 grammes (134 oz.) previously taken in the 24 hours were reduced to 500 grammes (17·6 oz.)—*i.e.* 3,300 grammes less. Or, taking the watery contents of solids and fluids together—

The quantity of fluid taken previously . .	=	4333·2	grammes.
,, ,, ,, in the new diet	=	979·4	,,
Amount discontinued	=	3353·8	,,

The carbohydrates were also further reduced :—

The quantity taken previously in solids and fluids	=	304·9	grammes.
,, ,, ,, in the new diet .	=	168·1	,,
Diminution	=	136·8	,,
As to fat, the previous quantity	=	64·7	,,
In the new diet the quantity	=	51·0	,,
Diminution	=	13·7	,,

The albumen-supply was not altered to an appreciable amount. While the patient's weight had steadily increased under the former diet, it was now lowered by *lessening the fluid* and carbohydrates and fat. He lost 9·570 kilos. (=21 lbs.) in fifty-five days (November 27, 1879, to January 21, 1880). This loss of weight was due in part to the removal of water from the tissues owing to the diminished water supply, and in part to more or less destruction of the fat deposited in the body, as investigation showed.

Reckoning the discontinuance of carbohydrates and fat together in the new diet as fat, we know that the 136·8 grms. of carbohydrates discontinued in the food are equal to 56·6 grms. of fat, which must all have been consumed, even to keep the body at the same weight as before. But about 13·7 grms. less fat were supplied

than before, and this loss must have been replaced by destruction of the body fat, so that the body had to give up daily in all 70·3 grms. of fat. This amounts in fifty-five days to a loss of 3·866 kilos., which deducted from the above total loss gives the water-loss = 5·704 kilos.

But according to Schmidt's analysis a body weight of 107·5 kilos. implies the weight of the blood to be 7·1 kilos., containing 5·6 kilos. of water. Accordingly, in the above case, supposing the loss of weight to be due to water only, the patient would have apparently lost 0·1 kilo. more water than his blood contained, an improbable conception. But, as investigation showed, the skin of the abdomen, breast, extremities, and neck had lost much of its fat; the previously tightly stretched skin was now thrown into folds, and only a moderate layer of fat covered the muscles. There is, therefore, no doubt that the greater part of the loss of weight was due to the loss of fat, and the smaller part to the loss of water.

The influence of reduction of fluids on fat-reduction we may explain in the way already mentioned, viz. that there was quicker dissolution and absorption of fat from anæmia and partial obliteration of large vascular areas of fatty tissue, and that owing to the more energetic activity of cells no longer nourished by a watery blood poor in oxygen, but by a blood richer in albumen and form-elements, the final decomposition of fat into carbonic acid and water was far more extensive than before. The severe winter not permitting outdoor exercise, no special gymnastics were undertaken, and the mode of life was unaltered except as regards the diet, so that there was no occasion for excessive consumption of fat.

With the rapid fat-reduction the circulatory disturbances also diminished more and more, so that by the end of January he had lost the previous distress from dyspnœic excitation, shortness of breath and palpitation, on walking or going upstairs. Between January 21 and February 28, his weight further decreased 4·5 kilos., so that the whole loss of weight between November 27, 1879, and February 28, 1880, was 107·5 − 93·43 kilos. = 14·07 kilos. (30 lbs.)

As soon as the weather permitted, long walks, lasting two or three hours, were taken, at first once a day, then twice a day, while the diet underwent no alteration. By the end of May the weight was only 86·5 kilos., thus giving a total loss of 25 kilos. within six months.

No more weighings were made, and the patient felt perfectly comfortable. During 1881 he removed from Munich.

TABLE I.—PREVIOUS DIET.

Fluids	Quantity in grammes	Water	Albumen	Fat	Carbo-hydrates	Analysis by	Solids	Total	Water	Albumen	Fat	Carbo-hydrates	Analysis by
Morning :							*Morning :*						
			Caffein										
Coffee	120	113·60	0·21	0·62	1·7	v. Voit	Bread (roll)	50	14·0	4·8	0·5	30·0	Renk
Milk	30	26·20	1·29	0·96	1·2	König							
Sugar	10	0·22	0·03	—	9·6	,,	*Midday :*						
Water	500	500·00	—	—	—	,,	Soup	300	254·1	7·8	9·6	29·1	Renk, average comparison of 10 kinds
Midday :													
Beer	500	453·00	—	—	25·0	v. Voit	Boiled beef	200	113·6	68·3	15·0	0·8	König
							Vegetables (cabbage, &c.)	100	71·0	1·7	0·4	8·3	v. Voit
Afternoon :													
Coffee	120	113·60	0·21	0·62	1·7	,,	Farinaceous food	200	90·0	17·4	30·0	57·8	Renk, average of 7 kinds
Milk	30	26·20	1·29	0·96	1·2	König	Black bread	50	17·7	4·1	0·8	26·4	v. Voit
Sugar	10	0·22	0·03	—	9·6	,,							
Water	500	500·00	—	—	—	—	*Evening :*						
Evening :							Roast meat, fowl or game	200	116·0	76·4	3·6	—	v. Voit
Beer	1500	1359·0	—	—	75·0	v. Voit	Salad (green)	50	47·1	0·7	1·0	1·1	König
Water	500	500·0	—	—	—	—	Black bread	50	17·7	4·1	0·8	26·4	v. Voit
Total	3820	3592·0	3·00	3·10	125·0			1200	741·2	185·3	61·7	179·9	

Total in solids and fluids in 24 hours :—

Water	4333·2 grammes	Fat	64·8 grammes
Albumen	188·3 ,,	Carbohydrates	304·9 ,,

TABLE II.—AMENDED DIET.

Fluids	Quantity in grammes	Water	Albumen	Fat	Carbo-hydrates	Analysis by
Morning :			Caffein			
Coffee . .	120	113·60	0·21	0·62	1·7	v. Voit
Milk . .	30	26·20	1·29	0·96	1·2	König
Sugar . .	10	0·22	0·03	—	9·6	„
Afternoon :						
Coffee . .	120	113·60	0·21	0·62	1·7	v. Voit
Milk . .	30	26·20	1·29	0·96	1·2	König
Sugar . .	10	0·22	0 03	—	9·6	„
Evening :						
Wine (Pfälzer)	200	172·30	—	—	6·0	König
Total . .	520	452·30	3·00	3·10	31 0	

Solids	Quantity in grammes	Water	Albumen	Fat	Carbo-hydrates	Analysis by
Morning :						
Bread (roll) .	50	14·0	4·8	0·5	30·0	Renk
Midday :						
Egg . . .	45	33·1	5·6	5·4	0·2	—
Beef (boiled) .	200	113·6	68·3	15·0	0·8	König
Vegetables .	100	71·0	1·7	0·4	8·3	v. Voit
Farinaceous .	100	45·0	8·7	15·0	28·6	Renk
Black bread .	50	17·7	4·1	0·8	26·4	v. Voit
Fruit . .	100	85·0	0·3	—	15·0	„
Evening :						
Egg . . .	45	33·1	5·6	5·4	0·2	—
Fowl, or game, &c. .	200	116·0	76·4	3·6	—	v. Voit
Salad . .	50	47·1	0·7	1·0	1·1	König
Black bread .	50	17·7	4·1	0·8	26·4	v. Voit
Total . .	900	527·1	169·1	37·1	136·6	

Total in solids and fluids in 24 hours :—

Water . . .	979·4 grammes	Fat	40·2 grammes
Albumen . . .	172·1 „	Carbohydrates . .	167·6 „

CASE IV.—Man, aged 66. *Obesity, fatty heart, and partial fatty degeneration, severe stasis, œdema in different places.—Remarkable lessening of fat and strengthening of the heart-muscle, compensation of the stasis and absorption of œdematous transudations.*

J. M., of private means, aged 66, of medium height, portly, corpulent, with much subcutaneous fat everywhere, puffy face, skin below eyelids œdematous. Slight cyanosis of lips and cheeks. Cardiac distress increased; sounds only faintly audible, pure; cardiac action irregular, 88 to 92 per minute. Normal state of diaphragm. Vesicular breathing audible over lungs with a few rhonchi. Pulse pretty frequent, small, empty between the beats, irregular, occasionally jerky. Appetite, digestion, and action of bowels regular. Urine non-albuminous. A slight apoplectic attack a year and a half ago. For a long time Herr M. has complained of gradually increasing dyspnœa, suffocation and palpitations, at first on going upstairs or ascending small neighbouring elevations, but later on when at rest also. Speaking is only possible in very short periods, especially if excited. The short breathing, sudden sweats, and exhaustion appear to increase daily. The patient, a lover of nature, was therefore obliged to restrict his accustomed and favourite walks, especially as the least chill was followed by a most obstinate and long-lasting bronchial catarrh.

From the complex of symptoms and after objective examinations, I diagnosed cardiac insufficiency from fatty deposition and degeneration of some of its fibres, venous stasis, insufficient decarbonisation of the blood, venous hyperæmia of the bronchi, and a catarrhal disposition. I therefore ordered deprivation of fluid as much as possible, an increased supply of albumen, and on the other hand increased perspiration by exercise.

The patient being accustomed to great regularity and simplicity in his food, we may safely assume that the following table gives fairly well the quantities of albumen, fat, and carbohydrates taken by the patient in the preceding year. (See Table I.)

In this table we remark at once the quantity of fluid (chiefly water) taken daily. He had been professionally recommended to take a copious supply of water on special grounds, both to diminish his fat and to lessen his difficulty of breathing by dilution of his blood. In contrast with this diet, which from the great quantity of fluid really threatened the patient's life, the supply of solids and liquids was rearranged as in Table II., and the meals there indicated were

adhered to for six months with very slight alterations. (See p. 221, Table II.)

The fluids taken in Table I.	=	3880	grammes.
" " " Table II.	=	570	"
Difference	=	3310	"

The total supply in grammes of water, albumen, fat, and carbohydrates in the solids and fluids was as follows :

	Water	Albumen	Fat	Carbohydrates
Table I. . .	4397·0	172·2	66·0	314·7
Table II. . .	984·7	183·1	38·1	142·7
Difference = .	−3412·3	+10·9	−27·9	−172·0

i.e. the albumen was increased 10·9 grms. daily, while the water, fat, and carbohydrates were lessened 3412·3, 27·9, and 172 grms. respectively.

Later on, when his condition underwent rapid improvement, the roast meats and salads were often replaced by farinaceous foods, and the diet was composed as follows :—

Water	Albumen	Fat	Carbohydrates
509·5	159·9	46·0	139·3 grammes

or, taking the average between the two diets,

528·2	170·2	40·7	125·1 grammes

while the fluids remained of the same composition—viz.

497·7	2·5	2·6	31·8 grammes

The exercise necessary both for increased water-excretion from the skin and lungs and for strengthening the heart-muscle was at first restricted to short walks of half an hour (the treatment beginning in October) once or twice daily; and not till next March were they extended to two, three, or four hours daily. As the patient stayed at Munich, these walks were on the level ground, small heights each side the Izar valley excepted.

The result of the dietetic regimen was wholly satisfactory. The patient's weight at the beginning of the treatment, October 15, 1875, was 98·5 kilos. (216·7 lbs.); after two months it sank to 89·25 kilos., with a loss of 9·25 kilos. After another two months (February 15, 1879) it was 86 kilos., or 3·25 kilos. less; and, finally, two months later (April 19) it was only 84·9 kilos.—*i.e.* 1·50 kilo. less. The loss of weight was accordingly 98·5 − 84·9 kilos. = 13·6 kilos. in six months.

TABLE I.—PREVIOUS DIET.

Fluids consumed daily	Quantity in grammes	Water	Albumen	Fat	Carbo-hydrates	Analysis by
Morning :						
Coffee . .	150	142·00	Caffein 0·26	0·78	2·2	v. Voit
Milk . .	50	43·70	2·10	1·60	2·0	König
Sugar . .	10	0·22	0·03	—	9·6	,,
Water . .	500	500·00	—	—	—	,,
Midday :						
Beer . .	500	453·00	—	—	25·0	v. Voit
Afternoon :						
Coffee . .	130	123·10	0·23	0·67	1·8	v. Voit
Milk . .	30	26·20	1·30	1·00	1·2	König
Sugar . .	10	0·22	0·03	—	9·6	,,
Water . .	500	500·00	—	—	—	
Evening :						
Beer . .	1500	1359·00	—	—	75·0	v. Voit
Water . .	500	500·00	—	—	—	
Total . .	3880	3647·40	3·95	4·05	126·4	

Solids	Quantity in grammes	Water	Albumen	Fat	Carbo-hydrates	Analysis by
Morning :						
Bread . .	50	14·0	4·8	0·5	30·0	Renk
Midday :						
Soup . .	200	169·4	5·2	6·4	19·4	Renk, average of 10 soups
Beef, boiled .	200	113·6	68·3	15·0	0 8	König
Vegetables (cabbage, &c.)	100	71·0	1·7	0·4	8·3	v. Voit
Farinaceous .	200	90·0	17·4	30·0	57·8	Renk, average of 7 kinds
Black bread .	50	17·7	4·1	0·8	26·4	v. Voit
Evening :						
Soup . .	150	127·0	3·9	4·8	14·5	Renk
Roast meat .	150	87·0	57·3	2·6	—	v. Voit
Salad . .	50	47·1	0·7	1·0	1·1	König
Bread . .	50	14·0	4·8	0·5	30 0	
Total . .	1200	750·0	168·2	62·0	188·3	

Total in solids and fluids in 24 hours:—

Water . . .	4397·0 grammes	Fat	66·0 grammes
Albumen . . .	172·2 ,,	Carbohydrates . .	314·7 ,,

Table II.—Amended Diet.

Fluids	Quantity in grammes	Water	Albumen	Fat	Carbo-hydrates	Analysis by
Morning :						
Coffee . .	130	123·10	Caffein 0·23	0·67	1·80	v. Voit
Milk . . .	20	17·40	0·86	0·64	0·79	König
Sugar . .	10	0·22	0·03	—	9·60	,,
Afternoon :						
Coffee . .	130	123·10	0·23	0·67	1·80	v. Voit
Milk . . .	20	17·40	0·86	0·64	0·79	König
Sugar . .	10	0·22	0·03	—	9·60	,,
Evening :						
Wine . .	250	216·30	0·21	—	7·50	,,
Total . .	570	497·70	2·50	2·60	31·80	

Solids	Quantity in grammes	Water	Albumen	Fat	Carbo-hydrates	Analysis by
Morning :						
Bread (roll) .	50	14·0	4·8	0·5	30·0	Renk
Midday :						
Beef (boiled) .	200	113·6	68·3	15·0	0·8	König
Vegetables (cabbage)	100	71·0	1·7	0·4	8·3	v. Voit
Roast meat .	150	87·0	57·3	2·6	—	,,
Salad . .	50	47·1	0·7	1·0	1·1	König
Black bread .	50	17·7	4·1	0·8	26·4	v. Voit
Evening :						
1 soft egg .	45	33·1	5·6	5·4	0·2	König
Roast meat .	150	87·0	57·3	2·6	—	,,
Salad . .	50	47·1	0·7	1·0	1·1	,,
Bread (roll) .	50	14·0	4·8	0·5	30·0	Renk
Total . .	895	487·0	180·6	35·5	110·9	

Total in solids and fluids in 24 hours:—

Water . . .	984·7 grammes	Albumen . . .	183·1 grammes
Fat	38·1 ,,	Carbohydrates . .	142·7 ,,

Here also the loss of weight was due both to water- and fat-reduction of the body. The muscular capacity increased in proportion as these were lessened, and walks of three or four hours long could be taken without fatigue. The cardiac action was quite normal again; the contractions energetic, slow, and regular; the cardiac dulness had decreased by nearly 1 cm.; the sounds were distinctly audible and pure. The venous stasis had disappeared; the arteries were better filled; the pulse was again full, strong, slow, and regular. The alarming respiratory phenomena, the sense of suffocation, the shortness of breath, did not recur now; speech was again possible in ordinary conversation and for a longer time than before, and the patient resumed his earlier activity, corresponding to a man of his age. The bronchial irritability depending on hyperæmia due to stasis disappeared also, and catarrhs of the deeper air-passages occurred more seldom and only for short periods.

Case V.—*Decided corpulency and fatty heart, cardiac insufficiency, severe venous stasis, œdema, gout.—Lessening of the body fat, strengthening of the heart-muscle, removal of the stasis, absorption of œdematous fluid.*

A. St., aged 58, a woman of private means of Zürich. For many years the patient, a tall, stately woman, who had always enjoyed good health, had developed a decided obesity in consequence of uterine trouble which confined her to bed for many months, and this had led to cardiac insufficiency and circulatory disturbances. From these circulatory alterations there presently set in shortness of breath, sense of suffocation, and asthmatic attacks, which extremely impeded all locomotion and more and more limited her walking. Sudden palpitations, and a sense of anxiety, and oppression at the breast tormented the patient day and night, and caused a gradual despondency and hypochondriacal turn of mind, which she sought to drive away by her native cheerfulness and by variety of companionship. The venous congestion developed in the respiratory organs a great disposition to catarrh of the mucous membrane, less troublesome in summer, and in winter she tried to oppose its greater development by a residence in Rome, which she had to visit yearly for her gout. When I first saw her, late in the autumn of 1879, besides the circulatory disturbances, the trouble due to the gout and the recurring pains in the different limbs formed her chief complaints, and the above symptoms were complicated in a troublesome manner by increase of uric acid and urates in the blood. Locomotion was extraordinarily difficult. The least movement, especially ascending a few steps, caused dyspnœa and

palpitation, obliging her to stand still. All effort was impossible, conversation was very limited, and her nights' rest and sleep were often extremely disturbed by dyspnœa and cardiac excitation.

On examination there was an extraordinary increase of the panniculus adiposus, and the enlargement of the cardiac dulness, so far as could be determined in spite of the fat and much enlarged breasts, indicated much cardiac fatty deposition, while the weak cardiac sounds and the small empty pulse indicated fatty infiltration and atrophy of the cardiac muscle. Vesicular breathing was heard everywhere. But the slight cyanosis of the skin and mucous membranes, especially on the cheeks and lips, pointed to the existing stagnation in the pulmonary circulation and the imperfect decarbonisation of the blood. As for the other organs, the liver was somewhat enlarged, the spleen less so, and the kidneys were in a condition of venous engorgement, and secreted a scanty urine rich in urates and slightly albuminous. An œdema, with pitting on pressure, reached from the ankles upwards about 15 cm. on either leg.

For the relief of the circulatory derangement, I resolved to unload the venous system by an energetic dehydration of the body. The fluid supply was reduced to a minimum, as in the earlier experiments, while no great restriction was placed upon the fat and carbohydrates, nor could it have been tolerated. I was the more anxious to avoid too albuminous a diet on account of the gouty tendency of the patient and the excessive formation of uric acid and urates, and I determined to leave the excess of deposited fat to be consumed later on under increased muscular action, especially walks and ascents. The removal of water was attempted in this case by pilocarpine injections.

Accordingly, I permitted her to board with some friends—*i.e.*, with only slight exceptions, to partake of the ordinary diet of the better classes in Munich, viz. roast and boiled meat, fowls or game, with some salad or green vegetables. Puddings also and bread were allowed to a limited extent. The drink was light wine and water. The food taken daily at different meals might be taken to represent 160 grms. of albumen, 30 to 40 grms. of fat (partly in butter, partly in other solids), and about 130 grms. in all of carbohydrates. The fluids amounted to 600 or 650 grms. at most.

To increase the water-removal, two injections weekly of pilocarpine were made from the end of October to the end of December, *i.e.* fifteen altogether. The first four each contained 0·015, the rest 0·02 grm. of pilocarpin-hydrochlor. ($\frac{1}{4}$ and $\frac{1}{3}$ gr. English respectively). The uncomfortable after-effects of pilocarpine were mostly limited to

temporary nausea, seldom vomiting, and a slight difficulty of breathing and feeling of oppression owing to the profuse salivary and mucous secretions, causing not only several hours' salivation but a continual coughing and hawking. During the intensity of its action large rhonchi were audible over both lungs, but there were never any true dyspnœic attacks or alarming cardiac symptoms. The patient felt as usual an hour, or at most two hours, after the injection. The watery loss was always copious, often extremely so, and if the saliva and mucus be included, the whole must have been 900 or 1,000 grammes. By the considerable restriction of the fluid supply and the increased cutaneous and salivary excretions, a steady diminution of the fluids of the body gradually ensued, first noticeable from its influence upon the circulatory derangement. The engorgement of the right heart subsided in proportion to this removal of fluid, so that after the ninth or tenth injection the patient was already able to walk farther than before without the palpitation and dyspnœa. She could also ascend three flights of stairs to her room without exciting the dyspnœa and the excessive cardiac action, which had previously compelled her to make several halts. Spontaneous palpitations ceased to trouble her now even at night; she often, and with pleasure, frequented the society open to her in Munich; and by the end of December, in spite of the inclemency of the weather, could walk for several hours out of doors without any circulatory or respiratory embarrassment, and without the catarrhs due mainly to venous congestion and resulting serous infiltration, as detailed in Case I. The easier cardiac action and the balance between the arterial and venous blood-volumes were more decidedly pronounced every day. The weight diminished from 95 to 83·5 kilos. (209 to 184 lbs.), and this loss was not due simply to diminution of the body fluids, but mainly to the removal of fat, as palpation and measurement showed. At the end of February, with the same diet, the injections were discontinued, the weight having sunk to 79·5 kilos. (*i.e.* 4 kilos. further, or 8·8 lbs.)

The residence in Munich and the time of year gave no opportunity for strengthening the heart, and the previous resolution was adhered to, viz. that the patient should pass the spring and summer amongst the Swiss mountains, and there endeavour to effect this by persistent exercise, and especially by the ascents of heights. As I have since learnt, the patient did this most satisfactorily, and regained a high cardiac energy.

CASE VI.—*Severe emphysema and circulatory disorder.—Temporary relief. Death from tuberculous pneumonia.*

The patient was a gold-worker, æt. 38. Mother and sister phthisical. Father and two brothers had died of phthisis.

Had suffered in childhood from chronic very obstinate bronchitis, and emphysema already existed at the age of fourteen. Till his twentieth year his symptoms received but scanty attention from his parents, and very little was done for them. When they became more violent, being accompanied by frequent severe and obstinate asthmatic attacks, and constant shortness of breath and œdema in the feet, he was sent from one health-resort to another, spent several winters in the north of Italy, and frequented various 'Therapeutic' and 'Natural-Cur' institutions.

Physical examination, November 13, 1878, revealed condensation extending across the apex of the left lung, with harsh expiratory sounds and rhonchi. Elsewhere over the left lung and over all the right lung there was emphysematous alveolar distension with diminished breath-sounds and extensive râles. Vital capacity 2,500 c.cm. Cardiac dulness somewhat enlarged, apex beat opposite sixth rib, the sounds pure and clearly audible. Second sound accentuated over pulmonary artery. Position of diaphragm four fingers' breadth below nipple. Liver dulness somewhat diminished. Face pale, slight cyanosis. Muscles weak, badly developed. Subcutaneous fat scanty. Much œdema of legs, reaching above knees. Urine very albuminous, with but few epithelial and hyaline cylinders. Body-weight 68·7 kilos. (151 lbs.)

To relieve the breathing was the first object; the circulatory disorders were of secondary importance. Owing to the loss of pulmonary elasticity, the alveolar distension, and the capillary obliteration over large areas, the pulmonary circulation was impeded and the right heart and great veins were overloaded with blood, while the aortic system was but scantily supplied with blood, and hence arterial anæmia. As in all such cases the disorder of the circulation had led to cardiac hypertrophy and dilatation, and secondary degeneration of the kidneys. Hence the treatment could only be *palliative.*

Even if by the energetic and continued influence of a high negative pressure upon the respiratory surface (by making expirations into rarefied air) a retraction of the lung tissue might be obtained, with enlargement of the vessels, a better flow of venous blood from the pulmonary arteries to the pulmonary veins, and a sufficient

compensation of the stasis, this mechanically effected compensation had to be furthered by a marked reduction of the blood-volume, and this again by a greatly increased excretion of water from the body. At the same time the pathological processes going on in the kidneys would be favourably affected by increased cutaneous excretion, the venal blood-pressure would be lowered, and the work lightened. Finally, it was to be expected that, under the continued influence of lessened atmospheric pressure and of the dehydration of the body, the dropsical transudations would be gradually reabsorbed and removed from the body. The patient procured for himself at my instance a Waldenburg's gasometric apparatus, that he might be able to breathe into a rarefied atmosphere as long and as frequently as possible.

As soon as the bronchial catarrh had somewhat subsided by inspirations of slightly compressed air, the patient commenced to make expirations into an atmosphere rarefied $\frac{1}{40}$th, three or four times daily for half an hour at a time. Later on the negative pressure was gradually increased to $\frac{1}{32}$ and even as far as $\frac{1}{25}$ and $\frac{1}{20}$ atmosph., while the time of action was raised to one hour. The pneumatic treatment was continued with slight interruptions from the middle of November 1878 to the end of April 1879. His supply of food and drink was regulated in the following manner, on the principles already developed : *Morning*, a cup of milk with a little bread ; *forenoon*, either nothing or one or two eggs, according to need ; *midday*, no soup, a good slice of roast (seldom boiled) meat, or the same quantity of two sorts of meat, a small help of green vegetables or salad, little or no bread. For desert, about 100 grms. of fruit ($3\frac{1}{2}$ oz.); during the *afternoon* a cup of milk or a little wine, in all 125 to 150 grms. ; *evening*, a couple of eggs, a slice of roast meat or game according to season ; and as a drink 190 grms. of wine and $\frac{1}{8}$ litre of water during the night.

A little fruit was also taken during the afternoon or evening. The following table gives the amount of food and drink taken daily, with the amount of water contained in each article.

The quantity of liquid was reduced by this diet to such a minimum as could be tolerated for a long period, and the patient now took from 1,500 to 2,000 c.cm. less liquid than before.

The water-excretions could not be increased in this patient by the same means as in the preceding cases, viz. by forced exercise and ascents, because the extensive emphysema from which the patient suffered would have still further intensified the alveolar distension during forced breathing, and would thus have increased the expiratory insufficiency. I tried therefore to increase the perspiration by other

TABLE OF AMENDED DIET.

Liquids	Weight in grms.	Water	Solids	Weight in grms.	Water
Morning :			*Morning :*		
Milk	150·0	131·0	1 roll	50·0	14·0
Midday :			1-2 eggs	45·0–90·0	33·1–66·2
Wine	125·0	108·1	*Midday :*		
Afternoon :			(Soup	100	91·6)
Wine (later			Roast meats	150·0	87·5
on [1])	125·0	108·1	Salad (green)	50·0	47·1
or Milk	150·0	131·1	Vegetables	50·0	35·5
Evening :			Flour food	70·0–100·0	31·5–45·0
Wine	190·0	164·3	Bread	25·0	7·0
Water	125·0	125·0	Fruit	100·0	85·0
			Evening :		
			2 soft eggs	90·0	66·2
			Roast meat	150·0	87·0
			Salad (green)	50·0	47·1
			Bread	50·0	14·0
			Fruit	50·0	42·5
Total	865·0	767·6		767·6	679·1

still purely physical means. During the winter months the patient took two, sometimes three, Turkish baths a week for about four weeks, then desisted two weeks and then began the baths again, and so on. On three occasions vapour-baths were substituted whilst the Turkish baths were closed on account of repairs.

The consequence of this treatment was most satisfactory ; the œdema had already disappeared for the most part by the end of the second series of Turkish baths, except for a little swelling about the ankles, and the urine had increased in quantity though it was never found free from albumen.

Moreover the respiratory disorders and the emphysema were benefited by his making expirations into rarefied air of the above-mentioned pressure three times a day for an hour or an hour and a half at a time. After a four months' treatment the vital capacity increased to 3,500 c.cm. I had occasion to make an interesting observation in the second month of the pneumatic treatment. An œdema of the hands had developed immediately after a sharp bronchial attack, and this œdema used to disappear when the patient made expirations for an hour into an atmosphere rarefied from $\frac{1}{25}$ to $\frac{1}{20}$. During the night the œdema would reappear, and for the sake of accuracy I let him begin the expirations earlier or later in the day

[1] After some improvement; if symptoms of stasis redeveloped, both the midday soup and the after-dinner wine or milk were discontinued.

than usual, but the swelling never disappeared until, after persistent breathing into rarefied air, a considerable aspiration of the venous blood by the lungs had occurred. If the expirations were left off for a whole day, the œdema not only persisted for that day, but considerably increased, and it required two or three hours' application of rarefied air to make it disappear next day.

I did not observe any influence of the rarefied air upon the œdema of the lower limbs, so that the pulmonary aspiration due to lowering of the intrapulmonary pressure appeared to expend its influence for the most part on the blood in the superior vena cava, the outflow from which is also necessarily under more favourable conditions than that from the inferior cava. The greater pressure of the blood accumulated in the veins of the lower limbs was shown by the œdema first appearing there, while that of the hands was a later event.

In the three sittings of an hour or an hour and a half each the patient breathed from thirty-six to forty cylinders-full into an apparatus constructed on Waldenburg's principle, and as from forty to forty-five expirations were required to fill each cylinder, he thus made between 900 and 1,600 expirations daily under a gradually increased negative pressure (*i.e.* into air gradually more rarefied).

On April 21 the patient's weight was 62·5 kilos., the loss of weight in five months being 3·1 kilos. This loss was chiefly due to the increased water-excretion from the skin and lungs, and a somewhat increased secretion of urine, for there had never been much obesity, and a reduction of fat was not contemplated in arranging the diet. The muscles were not deteriorated, but on the contrary were enlarged. They were also firmer and more resistant; their working capacity was raised, and the patient was not at all thinner compared with his previous condition.

As the objective symptoms gradually diminished the patient felt correspondingly improved. The respiratory embarrassment was strikingly less, there had been no dyspnœa or asthma since December, the slight bronchitis still present gave no trouble, and he could again walk for many hours daily without dyspnœa or palpitations.

In order to diminish still further the water of the blood, the patient in the ensuing summer took some 'sun-baths,' *i.e.* sweating-baths in a glass chamber like a hothouse. The illuminating and hot rays of the sun pass in easily through the glass, while the dark rays on the other hand do not pass out, so that the sun's heat can thus be greatly intensified. The influence of a July sun in such a place upon the perspiration is very great, and is often preferred by the patients to the artificial heat of the Turkish bath, both as to the

result and the manner in which it is effected. During July and August, according to the amount of the sun, the patient took several such 'baths' every week, and when they were discontinued he found that the œdema of the lower limbs had disappeared. Of course the same highly albuminous diet as before was persisted with, and the fixed quantity of fluids was not exceeded, in spite of the copious sweatings. His loss of weight during the summer months was nearly two kilos. (four pounds).

The pneumatic treatment was continued from April to October. with an occasional interruption of a week or a fortnight—on one occasion three weeks—according to his condition, or during absence from Munich, &c.

The consequence of the treatment under such unfavourable conditions was successful beyond all expectation, and when the patient looked back upon his former condition, which had not been appreciably altered at any health-resort or by any therapeutic measures, he felt justified in entertaining fresh hopes. The breathing was again free, the asthmatic attacks had ceased, the circulatory disturbances had subsided, and the general condition was improved.

In the course of the winter 1879–80 symptoms of tuberculosis, to which two brothers had already fallen victims, became more and more manifest, and necessitated alterations in the diet and general treatment, which however were without avail to check the disease, A pneumonia of rapid course carried him off in March 1880.

Case VII.—*Anœmia, with cardiac atrophy and insufficiency.—Improved blood-formation. Increased nutrition. Strengthening of the heart by mountain-exercise.*

Frau v. R., æt. 43, widow. Tall thin figure. White transparent complexion with blue veins visible through the skin, lips and gums pallid. Patient was moderately fat; her muscles were small and flabby. She had suffered for years in youth from anæmia and chlorosis, and still suffers from deficient blood-formation, weak heart, and nervous palpitations. Her short married life left her childless; she has been a widow ten years, and came under treatment during the past year in consequence of the continual aggravation of the above derangements, especially the cardiac.

The physical investigation of the patient only confirmed the above diagnosis. The pulse, 84 to 120 per min., was small, jerky, and irregular; the cardiac dulness was normal, if anything diminished; the sounds were pure but weak; the lungs healthy, as also the

abdominal organs. Appetite and digestion were regular, bowels somewhat costive, catamenia regular, lasting eight days.

Her mode of life was a perfectly regulated one, and excluded almost everything which could have an injurious effect. The diet, as usual amongst North Germans, comprised a large quantity of fluids, especially tea and water, the latter being taken freely, either alone or with a little light red wine. The patient cared little for society, and spent the day in music, reading, needlework, painting, and receiving or returning visits; avoiding, however, any long walks, as they were mostly followed by troublesome cardiac excitement, and had been repeatedly interdicted by her medical advisers.

Diagnosis.—Anæmia, complicated by cardiac debility and cardiac atrophy.

Any impression upon the circulatory derangements could only be made, firstly, by an improvement of the blood, with reduction of its constituent water; and, secondly, by strengthening the heart and increasing its muscular elements. The diet was accordingly altered, being made richer in albumen, but less watery than before, while iron was ordered in one form or another.

The new diet had the composition represented on the next page. Iron was taken in powder as the saccharated oxide, or else as reduced iron.

By this diet, therefore, the patient took daily only 520 grms. of fluid, or 1082·2 grms. of water in the fluids and solids together; 156·8 grms. of albumen, 45·3 grms. of fat, and 98·6 grms. of carbohydrates. She bore this restriction very well, being quite satisfied with this small allowance of water. There was no nervousness, sleeplessness, or other disturbances such as often follow deprivation of fat and carbohydrates as well as water. As the hydrostatic balance was not deranged at all, nor the venous apparatus overloaded with watery blood, a daily fluid supply of 700 to 800 grms. was permitted.

For the second task, the gymnastic strengthening of the heart-muscle, the patient was recommended daily walks, at first for two hours, then four hours, shared between the fore- and afternoon; at first on level ground, then gradually elevations of 100 to 300 metres were ascended. During the summer of 1883 she was recommended the Bavarian or Swiss mountains.

From May to October was accordingly spent partly in the Bavarian, partly in the Swiss mountains, and her mode of life altered correspondingly. The success now obtained was on the whole greater than had been anticipated. Her nutrition and strength were most satisfactory; she could walk for many hours, not only on level ground,

TABLE OF AMENDED DIET.

Fluids	Quantity in grms.	Water	Albumen	Fat	Carbo-hydrates	Analysis by
Morning :						
Tea . .	100·0	97·90	0·30	—	0·60	König
Milk . .	25·0	21·80	0·85	0·91	1·20	,,
Sugar . .	5·0	0·10	0·02	—	4·80	,,
Afternoon :						
Tea . .	100 0	97·90	0·30	—	0·60	,,
Milk . .	25·0	21·80	0·85	0·91	1·20	,,
Sugar . .	5·0	0·10	0·02	—	4 80	,,
Evening : . .						
Wine (Moselle)	62·5	53·10	—	—	1·30	,,
Water . .	62·5	62·50	—	—	—	
Spanish wine	20·0	11·34	—	—	5·68	,,
Extra :						
Water . .	125·0	125·00	—	—	—	
Total .	530·0	491·54	0·23	1·82	20·18	

Solids	Quantity in grms.	Water	Albumen	Fat	Carbo-hydrates	Analysis by
Morning :						
White bread .	35·0	12·4	2·4	0·2	19·60	König
Raw meat .	100·0	76·7	20·7	1·5	—	,,
1 egg . .	45·0	33·1	5·6	5·4	0·24	,,
Midday :						
Roast meat, Beefsteak, Game, &c.	150·0	87·5	57·3	2·7	—	v. Voit (av.)
Salad . .	50·0	47·1	0 7	1·0	1·10	König
Vegetables .	50·0	35·5	0 8	0·2	4·20	v. Voit
Puddings, &c.	100·0	45·0	8·7	15·0	28·90	Renk (av. of 7 kinds)
Fruit . .	50·0	42·5	1·5	—	7·50	v. Voit
Afternoon :						
1 egg . .	45·0	33·8	5·6	5·4	0·24	König
Evening :						
2 eggs . .	90·0	66·2	11·2	10·8	0·48	,,
Roast meat .	100·0	58·0	38·2	1·7	—	v. Voit
Salad . .	50 0	47·1	0·7	1·0	1·10	König
Bread . .	25·0	7·0	2·4	0·2	18·00	Renk
Total .	890·0	591·2	155·8	45·1	78·36	

but up pretty fair elevations, without any of the old distressing symptoms. The cardiac excitement, irregular imperfect contractions, and violent painful palpitations had entirely ceased, and only now and then a want of rhythm in the pulse indicated the previous serious condition. She was now able to do without the ice-bladder altogether, which used to be worn over the heart for many hours daily, and she could again take her place in society.

As she was in no way inconvenienced by adhering to the above diet for several months, no particular alteration was now made, except that a little more, both of solids and fluids, was permitted when she received visitors.

The exercise prescribed for the second task, that of strengthening the heart-muscle, was limited during the winter months to walks on level ground or slight ascents in the vicinity of the town.

A parallel case which I treated in the same year, and which gave the same gratifying results, was that of a Meiningen lady. The symptoms, indications, and treatment did not essentially differ from the above. The patient is still under treatment.

Case VIII.—*Mitral insufficiency and stenosis, imperfect compensation, commencing stasis.—Strengthening of the heart. Compensatory hypertrophy obtained by hill-climbing. Equalisation effected between arterial and venous blood-volumes.*

J. R., merchant, æt. 23. Had acute rheumatism in 1879 and in 1880, being confined to bed on the first occasion four weeks, on the second three. The endocardium was each time involved, and there remained mitral insufficiency and stenosis of the left auriculo-ventricular orifice.

Small as the objective alterations of the orifice and valve appeared to be, the symptoms induced were most troublesome, and after repeated examination I was forced to ascribe this to insufficient compensation, and to inability of the heart to overcome the hydrostatic derangement caused by the valvular failure, though but slight.

As the patient already suffered from cardiac excitement and shortness of breath even in gentle walking, and especially on mounting stairs, he had not only himself refrained from all exercise as much as possible, but his medical adviser had strictly prohibited all unnecessary movement, especially going upstairs, &c.

In consequence of this mode of life and the pretty free use of fat-forming foods, including one and a half to two litres of beer daily, there was a considerable development of fat, his weight had increased

to 75·5 kilos. (166 lbs.), and the advancing circulatory disorders were plainly manifest in the cyanotic coloration of the lips and cheeks.

When on examining the patient, March 12, 1882, I found the above circulatory alterations, and that this rapid development was to be set down to insufficient cardiac compensation, the treatment demanded appeared to me as follows :—

1. To lessen the work of the heart by a considerable restriction of the fluid supply and an increase of the watery excretions ;

2. To induce compensatory cardiac hypertrophy by exercise, especially ascents of hills.

I accordingly lowered the fluid supply from 3,500 c.cm. to 600 or 700 c.cm., and fixed the albumen of the diet at 150 grms., the fat at 22 grms., and the carbohydrates at 80 grms., in the 24 hours.

In order to increase the watery loss from the skin and lungs, the patient during the first few weeks, no expeditions being practicable owing to the weather, took twelve Turkish baths at the rate of two a week, and walked for about an hour and a half each morning and afternoon, after ascending small neighbouring elevations of ten or twelve metres. In May he went to Miesbach, where the hilly country gave him an opportunity of carrying out the treatment better. Twice a week some small hill was ascended, such as Sadelberg, Pennberg, Taubenberg, and on other days a walk of two, three, or four hours was taken, shared between the fore- and afternoon.

From July to the middle of September he stayed alternately at Tegernsee and Schliersee, and by September was already able to ascend the Wendelstein slowly and without cardiac trouble. He now rapidly improved. The spontaneous palpitations and dyspnœa which had previously so frequently followed exertion disappeared ; the pulse was full, strong, and regular ; and violent palpitations only set in on climbing high elevations, and then soon subsided on his standing still and taking a few deep inspirations. Walking on level ground gave him no trouble, nor did the ascent of small heights. The slight cyanosis of the lips and cheeks had disappeared, and the circulatory disorder was not apparent in the face.

The conclusion may safely be drawn that a compensation of the irreparable damage had taken place, *i.e.* a compensatory hypertrophy of the heart. Percussion and auscultation, however, revealed no alteration directly answering to this. The heart-sounds were certainly louder, but the systolic and diastolic mitral murmurs persisted. Percussion showed only a slight enlargement of cardiac dulness, and this was not new.

Finally, there was decided diminution of fat, and his weight was

now 60·5 kilos. (133 lbs.), showing a decrease of 15 kilos. (33 lbs.) between March 12 and September 17. Albuminuria was never found. The patient is still under treatment.

CASE IX.—*Fatty degeneration of the heart. Failure of compensation. Severe venous engorgement.—Diminution of latter. Improvement of compensation. Relapse from excess of fluid supply. Observations on water-excretion from the kidneys, skin, and lungs, with diminished water-supply, and in the presence of extensive œdema.*

My last case is one in which the disease had already advanced so far that rectification of the circulatory disorder was out of the question, but this case gave occasion to so many interesting observations on the supply and excretion of water as to justify its publication.

J. Sch., æt. 58, affected with scoliosis of the upper dorsal vertebræ and compensatory cardiac hypertrophy (the patient on whom the egg-feeding experiments were made), had severe shortness of breath in the beginning of the year 1883, especially on moving about. This was his first serious indisposition, to his recollection.

On February 10 he was awaked from sleep by a sense of suffocation; his heart beat strongly and his pulse was very rapid, so that at daybreak he determined to call in medical aid. His doctor diagnosed dilatation and over-exertion of the heart, ordered digitalis to calm its action, and recommended perfect rest and withdrawal from business for a time. After a few doses of digitalis the breathing became easier, the palpitations ceased, the appetite improved, and the patient thought all danger was over.

In April, however, having resumed his usual mode of life, the above symptoms reappeared in still greater severity, and digitalis had now no influence upon them. He now had a hard time of it, though still remaining at his business, his symptoms being far more tolerable during the day than by night. Every evening he went to his usual place of resort, took two large glasses of beer (1 litre) and some food —he had no appetite though—in order to sit there longer and thus shorten his wretched night. As before said, the respiratory and circulatory embarrassments were most pronounced after exertion, and were greatly lessened by rest. He went to bed at this period usually at 10 or 10.30 P.M., and towards 1 or 2 A.M. was regularly waked by a severe sense of suffocation, which gave him no further sleep that night. All he could do was to lie quiet and turn occasionally in bed. But soon his condition became still worse.

Towards the middle of May, his dyspnœa was so great that he could not rest in bed beyond an hour and a half or two hours. In his distress he scarcely knew what to do, but walked up and down the room half the night, opened the window now and then and gazed out of it, and then threw himself exhausted into a chair, facing apparent death from suffocation. This dreadful state of things lasted all through May, so that he often longed for death to end his troubles.

He could hardly walk three steps without being obliged to stop and gasp for air, and even at this rate could not go on more than three to five minutes without having to rest altogether. Even speech was denied him, owing to his want of breath. His meals were very scanty—a cup of tea with a little bread in the morning, at midday some meat soup with an egg, and in the evening nothing but a glass or two of beer, because he thought beer helped him to sleep. The night of the 24–25th of May was the most terrible during his whole sickness, and on the 26th I was asked to see the patient by my friend his medical attendant.

Present Condition.—Patient of medium size, scoliosis of upper dorsal vertebræ, very little fat, decided cyanosis of skin and mucous membranes. Breathing rapid and superficial, speech affected by the constant want of breath, slight cough. Pulse 120–130, small, irregular, jerky. Thorax compressed on right side by the projection of the dorsal vertebræ; ribs bent at posterior third, straighter anteriorly. Cardiac dulness reaches from the third to beyond the sixth rib, overlapping the right sternal border and the left nipple line by two centimetres. Œdema, pitting on pressure, reaches half-way to the knee. On auscultation, vesicular breathing is heard, together with a few rhonchi; vital capacity 1,250 c.cm. Weight 52·65 kilos. (116 lbs.) Urine slightly albuminous, no casts.

Diagnosis.—Scoliosis of vertebral column. Cardiac hypertrophy, especially of the right ventricle; deranged compensation.

The indications for treatment were thus clear enough, viz. the *lessening of the quantity of blood* with equalisation of the arterial and venous pressures by diminution of the fluids of the body, and *the restoration of the lost compensation* by strengthening the heart-muscle. The patient's age and general debility, together with the duration and degree of the affection, gave no chance of a real cure, but the above indications afforded some probability that his position might be rendered more endurable by this than by any other method. The history showed that the supply of solids and fluids on Sundays and holidays had differed somewhat from the usual supply, and on the side of excess. The following table gives the contrasted figures. The

TABLE I.—PREVIOUS DIET.

Fluids	Usual daily supply			Sundays, &c.		
	Quantity in grms.	Water contained		Quantity	Water contained	
		Minimum	Maximum		Minimum	Maximum
Morning :						
Coffee . .	120	113·6	113·6	120	113·6	113·6
Milk . . .	30	26·2	26·2	30	26·2	26·2
Midday :						
Beer . . .	250	226·5	226·5	250	226·5	226·5
Coffee . .	—	—	—	120	113·6	113·6
Milk . . .	—	—	—	30	26·2	26·2
Afternoon :						
Beer . . .				1,000–1,500	906·0	1359·0
Evening :						
Beer . . .	1,500–2,000	1359·0	1812·0	1,500–2,000	1359·0	1812·0
Total .	1,900–2,400	1725·3	2178·3	3,050–4,050	2770·6	3676·6

Solids	Quantity in grms.	Water contained	
		Minimum	Maximum
Morning :			
2 eggs . .	70	30·0	30·0
Midday :			
Soup . .	360	242·6	331·2
Beef . . .	140	72·1	72·1
Salad . .	70	65·9	—
Vegetables .	170	—	120·7
Bread . .	50	14·0	14·0
Evening :			
Soup . .	360	—	242·6
Veal . . .	130	—	85·8
Potato salad .	140	—	111·8
Green salad .	70	65·9	—
Smoked meat .	70	22·3	—
Bread . .	50	14·0	14·0
Total .	1,680	526·8	1022·3

occasional substitution of fowl or game for the usual beef need not be noticed, and the difference of the water-supply is only infinitesimal. According to the table, therefore, the average daily amount of fluids was 2,150 grms., reaching 4,050 grms. on Sundays and holidays and special occasions. The total quantity of water in the solids and fluids ranged from a minimum of 2251·1 grms. to a maximum of 4698·8 grms.

In order to effect a speedy and efficient removal of water from the body, I reduced the fluid-supply considerably, the solids being unaltered. Both the midday and evening soup were stopped, an egg with some bread being given in the forenoon. Between the 11th and 22nd of July occurred the egg-feeding experiments already described, and during this time the diet was altered altogether. I sought to produce increased watery excretion from the skin and lungs by exercise, but, as this was exceedingly troublesome to him and caused great embarrassment of the breathing, he went only very short distances at first, gradually extending his walks as the breathing became freer and the venous stasis diminished.

TABLE II.—AMENDED DIET.

Fluids	Quantity in grms.	Water contained		Solids	Quantity in grms.	Water contained	
		Min.	Max.			Min.	Max.
During the day:				*Morning:*			
Milk . .	130	113·5	—	Wheat bread.	70	30·0	30·0
Wine . .	260	225·0	—	1 egg . .	45	—	31·1
Water . .	130	130·0	—	*Midday:*			
				Boiled beef .	140	72·1	72·1
				Salad . .	70	65·9	—
				Vegetables .	170	—	120·7
				Bread . .	50	14·0	14·0
				Evening:			
				Roast veal .	130	—	85·8
				Potato salad.	140	—	111·8
				Smoked meat	70	22·3	—
				Bread . .	50	14·0	14·0
Total .	520	468·5	—	Total .	935	218·3	479·5

Table II. gives the average daily quantities of food and drink in the new diet. Thus the patient now took only 520 grms. of fluids, containing 468·5 grms. of water, and the amount of water in the solids varied between 218·3 grms. and 479·5 grms.

Let us compare these figures with the preceding.

—	Fluids, in grms.		Water in solids, in grms.	
	Minimum	Maximum	Minimum	Maximum
Previous fluid supply . .	1,900	4,050	526·8	1022·2
Reduced supply . . .	520	520	218·3	479·5
Difference . .	1,380	3,530	308·5	542·7

Thus the fluids were reduced to between 1,380 grms. and 3,530 grms., *i.e.* between a fourth and an eighth of the previous amount daily imbibed and passed into the circulation.

In the solids the contained water was lowered from 308·5 grms. to 542·7 grms.

In severe circulatory disturbances, when large quantities of water (chiefly in the fluids) are quickly taken, and only slowly excreted, to the prejudice of the venous circulation, the reduction of the fluids supplied must presently affect the circulatory processes to a remarkable degree. And such was the case here. Even after a few days only the patient felt much freer, the breathing was easier, walking was possible and for longer stretches than before, his nights were now tranquil, and he could again lie down. As the June days were mostly sunny and the temperature pretty high, the loss of water from the skin and lungs, though always small in this patient, was very considerable, especially when he gradually undertook more prolonged exercises.

As it is interesting to observe how the excretion of water by the kidneys, skin, and lungs, is influenced by a great reduction of the fluid supplied, I have compiled the following table from the very careful weighings and measurements made by the patient himself. The figures representing the water contained in the solid food do not pretend to absolute accuracy, but may be regarded as fairly approximate values.

As a glance at the table shows, not only was the imbibed water perfectly excreted in the urine, but the latter contained an excess, due to the water contained in the solids of the diet. On the other hand, the amount remaining for excretion by perspiration and pulmonary exhalation is extremely small. The highest value is only 508 grms., whilst it is twice negative, −27·4 and −28 grms., and on these occasions the urine reached the maximum values of 800 and 780 grms. respectively. When more water was taken in the food, as on June 15, 18, 20, and 22, the urine was somewhat increased, but

TABLE III.—SUPPLY AND EXCRETION OF WATER.

Date	Water-supply in grms.			Water-excretion as urine, in grms.	Remainder (by lungs, skin, &c.)
	In fluids	In solids	Total		
June 1	468·0	387·1	855·1	688·0	167·1
,, 2	477·3	406·7	844·0	698·0	186·0
,, 3	468·0	376·7	844·7	554·0	190·7
,, 4	468·0	405·2	873·2	624·0	249·2
,, 5	468·0	443·3	911·3	604·0	307·3
,, 6	468·0	407·8	875·8	634·0	241·8
,, 7	559·8	494·5	1054·3	654·0	400·3
,, 8	468·0	413·3	881·3	668·0	213·3
,, 9	468·0	443·2	911·2	510·0	401·2
,, 10	468·0	314·1	782·1	530·0	252·1
,, 11	468·0	649·9	1117·9	718·0	399·9
,, 12	468·0	693·7	1161·7	708·0	453·7
,, 13	468·0	534·3	1002·3	738·0	264·3
,, 14	468·0	624·1	1092·1	772·0	320·1
,, 15	468·0	788·0	1256·0	748·0	508·0
,, 16	468·0	302·0	770·0	698·0	72·0
,, 17	468·0	284·1	752·1	738·0	14·1
,, 18	468·0	822·1	1290·1	812·0	478·1
,, 19	468·0	304·6	772·6	800·0	−27·4
,, 20	468·0	761·6	1229·6	772·0	457·6
,, 21	468·0	377·0	845·0	719·0	126·0
,, 22	468·0	808·3	1276·3	792·0	484·3
,, 23	468·0	391·5	860·5	697·0	163·5
,, 24	576·4	417·8	994·2	701·0	293·2
,, 25	468·0	503·0	971·0	752·0	219·0
,, 26	468·0	284·0	752·0	780·0	−28·0
,, 27	468·0	309·0	777·0	650·0	123·0
,, 28	468·0	414·7	882·7	644·0	238·7
,, 29	468·0	430·3	898·3	635·0	263·3
,, 30	468·0	387·8	855·8	643·0	212·8
July 1	599·1	304·1	903·2	677·0	226·2
		Total .	29333·4	21462·0	7871·4
		Average daily amount .	946·2	692·3	253·9

without reaching its highest values, while the amount of water excreted by the skin and lungs was more largely increased. Any further loss of water by normal or increased sweating than the above figures indicate must be regarded as given off from the body itself.

Weight of the body before deprivation of water .	= 52·650 kilos.
,, ,, after ,,	= 48·100 ,,
Loss of weight	4·550 ,, (= 10 lbs.)

No particular decrease of the body-fat, which was always scanty, could be made out by numerous careful examinations, and from the patient's general condition we must conclude that there was very

little fat about the viscera. This loss of weight then of 4·55 kilos. must have been due solely to loss of water from the tissues, chiefly from the blood. How quickly this loss went on was shown by the disappearance of the œdema from the lower limbs as early as June 7.

Reckoning the loss of weight as due to loss of water, and allowing for the perspiration, we obtain a loss of 146·8 grms. per diem, which, added to the above sum, gives a daily average of 400·7 grms. Even this quantity is extremely small, according to the values found by Pettenkofer and myself for the loss of water from the skin and lungs, and hence we may conclude that after a thorough removal of all the (spare) water of the body *the cutaneous excretion is considerably diminished,* though it may be temporarily greater from excitation of the sweat glands by exercise or external warmth. The observations which we have occasion to make on such patients perfectly agree with this. When the loss reaches a certain degree, the skin becomes dry even in regions usually moist, the perspiration in the axillæ and on the soles of the feet gradually ceases, and the skin may become hard and dry on the hands and feet, while intense excitation is usually required to produce sweating, previously so easily provoked. Moreover the cutaneous activity was always very small in this patient, which helps to explain the low figures. We shall by-and-by enter into fuller details on this point.

In these investigations the proof is given us by figures that with a reduced fluid supply, none of the water introduced into the body remains there, but that there is a limit in the supply, below which not only is the water supplied completely excreted, but some of that accumulated in the blood and tissues is removed by perspiration and respiration.

As to the final result of this dehydration of the body and lessening of the blood-volume carried on for thirty-one days, it must be regarded as perfectly satisfactory in every way. The symptoms of stasis all disappeared, the patient breathed freely and easily, could take long walks without much fatigue or shortness of breath, and could even ascend heights of 100 to 200 metres, though slowly and with frequent pauses. The spontaneous palpitations had ceased; sleep was again possible in the recumbent position. The pulse was strong and regular, the œdema and cyanotic tint had disappeared, and the urine was perfectly free from albumen. It only remained to strengthen the heart-muscle by exercise, as already detailed, and I therefore recommended residence in a hilly country, so as to give the best opportunity for methodical walking and ascents. As I was about to

take my holidays I left the patient to himself, hoping that he would earnestly carry out my directions.

When I saw him again at the end of September, the old troubles had recommenced. The circulatory disorder had not only attained the previous severity but far exceeded it, the want of breath was extreme, walking and also lying down were impossible. The pulse was irregular, jerky, scarcely to be felt. Œdema had reappeared on the feet, and reached to the middle of the thigh. The hands, especially the right hand, were much swollen, and so was the face. The urine was albuminous. Shortly after my leaving Munich the patient had unfortunately met with a physician who unluckily said he might take half a litre of wine in the forenoon and one or two glasses of beer in the afternoon and evening without harm, for the sake of strengthening himself. This advice he had only too gladly accepted on changing his residence, where he had diligently exercised himself and had ascended considerable elevations. He drank daily under various forms from two to two and a half litres of fluid.

Forced by necessity, he had already sought help before my arrival in Munich, but without deriving any benefit from the usual internal remedies : digitalis, acetate of potash, and 'Tart. borax.' The indications were the same as in the former illness, while the prognosis had become much graver. As the threatening symptoms were more numerous and the strength weaker, I attempted—a residence in a southern climate being out of the question—to effect a gradual unloading of the circulation and the retrogression of the œdema, by *reducing the supply of fluids*, and *increasing the water-excretions*. I therefore arranged a diet in which the fluids should not exceed 520 grms. containing 468·6 grms. of water, while the water contained in the solid food was only 400 grms., the total amount being thus 870 grms. in twenty-four hours.

This amount was adhered to all the more easily as the appetite was very poor from lowness of spirits, and the amount of water indicated in the solids was not at first reached. We may therefore consider 570 grms. to be the maximum.

An increased excretion of water, which at the patient's desire I had endeavoured unsuccessfully to bring about by diuretics, I now attempted to produce by increased sweating in the dry heat of the Turkish bath. A daily bath was recommended, the patient to stay as long as possible in the tepidarium and sudatorium. As in the experiments on healthy people (see page 59), estimations of the watery loss were made. The patient's weight, 48·1 kilos. in June, was

now 56·5 kilos., and this increase of 8·4 kilos., as shown by the general nutritive condition, was exclusively due to the water accumulated in the blood and tissues. This was the task then, to effect the gradual excretion of 8·4 kilos. of water. Between October 7 and 18 the patient took twelve Turkish baths in Kolditz's establishment in Munich, and after an interval of eight days a second large series, viz. eight baths by November 2. The degree of evaporation from various cutaneous regions (the palms, sternum, both infraclavicular regions, the mid-femoral and anterior tibial regions, and the dorsal surfaces of the feet) was determined by Dr. Erhardt's atmometer,[1] made in Rome.

TABLE IV.

No. of experiment	Date	Body-weight in kilos.	Urine in c.cm.	Loss of weight in bath in grms.	Degree of evaporation on Erhardt's atmometer						
					Palms	Sternum	Left side of chest	Right side of chest	Thigh	Leg	Back of foot
1	Oct. 7	56·500	920·0	200·0	—	—	—	—	—	—	—
2	,, 8	56·350	870·0	200·0	—	—	—	—	—	—	—
3	,, 9	56·400	790·0	400·0	—	—	—	—	—	—	—
4	,, 10	56·300	810·0	300·0	—	—	—	—	—	—	—
5	,, 11	56·100	770·0	400·0	—	—	—	—	—	—	—
6	,, 12	55·800	790·0	300·0	30	18	22	22	22	12	10
7	,, 13	55·600	780·0	250·0	32	18	18	14	22	18	8
8	,, 14	55·400	740·0	100·0	26	20	20	20	16	12	2
9	,, 15	55·500	810·0	300·0	30	24	20	22	21	14	6
10	,, 16	55·700	800·0	200·0	40	19	22	20	16	6	0
11	,, 17	55·700	770·0	300·0	31	22	23	24	20	11	0
12	,, 18	55·700	740·0	200·0	32	21	23	20	18	9	0
13	,, 26	54·250	920·0	250·0	24	19	20	21	18	7	0
14	,, 27	54·000	810·0	450·0	40	21	18	22	14	10	0
15	,, 28	53·150	840·0	650·0	47	21	22	22	24	15	9
16	,, 29	52·300	810·0	500·0	44	20	19	21	19	14	10
17	,, 30	52·350	850·0	450·0	38	21	21	21	20	12	7
18	,, 31	52·200	860·0	450·0	22	18	19	19	20	8	0
19	Nov. 1	52·400	820·0	500·0	22	18	19	18	18	11	0
20	,, 2	52·350	840·0	550·0	40	19	20	20	18	10	8

[1] Erhardt's atmometer consists of a glass segment of a circle, 2 cm. in breadth, divided into 70° and subdivided down to $\frac{2}{10}$°. This is joined to two somewhat wider pieces of caoutchouc, each 5 or 6 cm. in length, connected together at an acute angle. The lower plate has a border, and bears a gelatine tongue 4·6 cm. long and 1·8 cm. broad. This strip of gelatine, laid upon the surface to be examined, takes up the water evaporated, and by its corresponding degree of outward curvature allows the relative value to be read off at once on the glass arc. (This instrument is made by Katsch, of Munich; price eight shillings.)

Now after the experiments on the influence of hot dry air upon the perspiration, I expected a great increase of the latter in this patient. Quite the contrary took place, however; the cutaneous and pulmonary water-excretion was relatively small, and during twelve baths only twice reached 400 grms., sank once to 100, and gave an average of 262·5 grms. Only in the later baths, October 26 to November 2, did the amount begin to increase and in some degree approximate that obtained experimentally. The loss of weight which for the above reasons we must set down to loss of water, lay between a maximum of 650 and a minimum of 250, with an average of 450 grms.

The cause of this surprising fact was evident during the first bath, for *no sweating occurred on the œdematous regions* of the body, and the tense skin remained perfectly dry even in the sudatorium at a temperature of 60° C. (140° F.) It was also noticed at the same time that such parts did not get warm in spite of the high temperature, and the legs and feet were cold even after an hour's stay in the bath. In support of this explanation is the fact that *the perspiration is a real secretion*, and wherever the glands and their surrounding capillaries were compressed by the œdematous infiltration, no evaporation occurred, although there was an abnormal amount of water beneath the epidermis, which ran off on pricking with a needle, and the whole skin was tense, thinned, and with at least some of its pores widened. But even the other sweat-glands acted badly, the arterial supply to their capillaries being so poor owing to the enormous degree of venous congestion, and thus giving no opportunity for increased excretion. The difference between the sweat-secretion in mountain-climbing (where, from lowering of the vascular tension, the cutaneous capillaries are dilated and contain more blood), and that in the Turkish bath, where no such influence is brought to bear on the blood-distribution and the depressors of the vascular apparatus, is very striking.

The comparative atmometric observations are also very interesting. In accord with our remarks on the Turkish bath, the œdematous regions gave the lowest values, in proportion indeed to the swelling and tension of the skin. This was notably the case on the dorsum of the foot, where the amount was only just above zero, and on seven occasions was zero. The greatly swollen leg gave only a very slight degree of evaporation, varying between 6° and 18°, the average being 11°. The amount over the middle of the sternum and on each side of the chest varied between 18° and 24°, while on the palm of the hand the instrument quickly indicated 47°, and even the minimum was 18°.

These remarks complete our observations on the Turkish bath and establish the fact that *no secretion of water occurs* to any appreciable extent *over œdematous parts.* The proof is again afforded that the act of sweating is not a simple process of evaporation, otherwise it would occur most abundantly over œdematous areæ, there being water enough present here, and every requisite condition for evaporation.

On the last weighing, after the twentieth bath, on November 2, the body-weight was 52·350 kilos. The weight before beginning the baths being 56·5 kilos., we thus have a loss of weight of 4·18 kilos. (9 lbs.) during twenty baths, the time spent in the tepidarium (at about 52° C.) being $\frac{3}{4}$ hr., and that in the sudatorium (at about 60° C.) $\frac{1}{4}$ hr. As the diet was unaltered and there was no increased tissue-change from walking or other exercise, we must ascribe this loss of weight to *loss of water from the body.* And, in accordance with this view, the water infiltrating the subcutaneous cellular tissue of the lower extremities was in great part reabsorbed, and given off by the kidneys, skin, and lungs, and the œdema now ceased halfway up the shins.

Through this by no means inconsiderable removal of water from the tissues the breathing became freer again, the violent palpitations abated, the general cyanosis diminished, exercise became easier, and the muscular power increased. The patient could once more walk a good distance without any great embarrassment of the breathing, and he could move about the house without trouble.

It is very questionable how far these symptoms of restored compensation will be permanent, and it is hardly doubtful that the latter will be of only short duration. As already stated the conditions are no longer present for a lasting restoration of the hydrostatic balance, and the help afforded can be only palliative. In this advanced season of the year our climate does not afford the opportunity for instituting a 'gymnastic' of the heart by walks and ascents, indispensable though these may be, and a winter in the south was impracticable for him. The weight has not been taken lately, but the latest observations show a decided diminution of urine, whilst albumen is gradually making its appearance.

Nevertheless this case is so interesting and instructive, not only in pathology and treatment, but physiologically also, that I could not refrain from introducing it here with all the particulars.

RESULTS OF FOREGOING CLINICAL OBSERVATIONS.

1. In all the cases of obesity and fatty heart, with more or less advanced venous stasis, which we have had occasion to treat, fat-reduction has been rapidly and thoroughly effected, without the development of secondary disturbances of any kind. That is to say—

a. In no case was an albumen-destruction observed greater than the albumen-supply.

b. Large quantities of albumen were digested and absorbed without causing any intestinal derangement.

c. The debility which so often appears as a consequence of a rigid 'Banting' method, was never caused.

d. Cardiac paresis, hydræmia, and secondary kidney disease have never occurred during the last nine years in any of the fifteen cases of obesity with circulatory derangement.

2. Rapid reduction of fat (together with freer respiration, a larger supply of oxygen, and increased muscular power) is a consequence of the energetic removal of water from the body in cases of obesity and advanced circulatory disorder.

3. When there is already considerable venous stasis, the withdrawal of water from the tissues by a diminished fluid-supply, and by increased fluid-excretion, is the only useful measure to adopt.

4. The dry hot air of the Turkish or of the 'sun bath' is an appropriate physical means of inducing increased water-excretion from the skin.

5. Also the sweating and salivation caused by pilocarpine injections may be successfully used as a means of increasing the water-loss of the body, in circulatory derangement not too advanced.

6. Case I. and (in part) Case XVIII. exhibit the great influence which we can exert upon the heart, vessels, and quantity of fluid in the body, even in severe circulatory disease.

7. On the other hand Case IX. teaches us how, in advanced derangement of the circulation, after successful treatment of the stasis, the hydrostatic balance was disturbed afresh by the patient's exceeding the quantity fixed upon for the fluid supply,

and how the degree of the resulting relapse depended upon the degree of excess.

8. From observation of the same case we learn the following facts also :—

a. That the daily quantity supplied to the vessels, in circulatory disorders, if it does not exceed a certain (small) amount, is again perfectly excreted within twenty-four hours by the kidneys, skin, and lungs ; and moreover that in cases of venous stasis, hydræmia, and œdematous infiltrations, we can diminish the accumulation of water in the tissues by lowering the supply of liquids to a certain minimum quantity.

b. That the high temperature of the Turkish bath has no influence, or only a very slight one, upon œdematous swellings ; and that the evaporation from the surface is nil or inappreciable over œdematous parts, in proportion to the amount and hardness of the swelling and the tension of the skin.

c. Finally, the phenomena mentioned prove that sweating is a true secretory act and not a simple physical process, not a mere evaporation.

9. In all the cases, by observing a proper proportion in the reduction of the fluid supply, and by careful additions to and subtractions from the diet, all troublesome nervous symptoms were perfectly avoided—*e.g.* mental excitement, sleeplessness, and mental depression, so apt to follow diet-cures carelessly planned.

MANAGEMENT AFTER CORRECTION OF THE CIRCULATORY DERANGEMENTS.

When once the circulatory disorders and venous stasis, however caused, are removed, the hydrostatic balance readjusted, and sufficient compensation re-established, our last task is to guard against a too speedy loss of the improvement, and a fatal advance of incurable processes.

Such patients must be placed in the category of those in whom the circulatory apparatus has indeed endured an injury, but in whom a sufficient compensation has been re-established, so that that injury is borne without much harm.

In both cases we must be careful that the heart, acting as a pump, is in a condition to receive and transmit the blood passing to it, so that no harmful stasis occur in the afferent vessels with excessive pressure upon their walls. Since the regulation of this is greatly dependent on the nutrition of and supply of fluids to the body, as well as on the functional activity of the heart itself, the mode of life of these patients must be directed according to clearly defined principles, which may be regarded as the 'dietetic of circulatory irregularities.'

According to the facts revealed by the above cases, this dietetic or general management may be divided into the following parts:—

1. Strengthening the heart-muscle.
2. Preservation of the normal composition of the blood.
3. Regulation of the quantity of fluid in the body.
4. Prevention of fatty deposition and obesity.

1. As to the first task, *the strengthening of the heart-muscle*, we must ever remember that *the heart is a muscle*, the strength and functional capacity of which are increased by all those influences which strengthen other muscles. By exercise a muscle becomes proportionately hypertrophied, and its functional power increased. Also for the heart-muscle exercise is the only means we have for strengthening it, and, as the above examples show in the most striking manner, it is best exercised by calling forth powerful contractions by locomotion, to some extent on level ground, but especially by the ascents of hills and mountains. This subject has been neglected far too much, and such patients have been forbidden all bodily exertion, including long walks and ascents, in order that the heart especially might be spared and all palpitations and discomfort avoided. But this advice always injures the patient, and favours fatty infiltration into the already hypertrophied heart, instead of causing the hypertrophy to be maintained and the heart to be strengthened.

Such patients must take as much *exercise* as possible, and must ascend heights according to their health and strength, without being frightened at the violent palpitations caused thereby, since cardiac excitation is the object aimed at. The exercise must be continued indeed until the latter is caused, and the patient must thereupon stand still till it has abated,

and until the simultaneous shortness of breath is satisfied by (voluntary) long, deep inspirations. Sitting down and resting altogether must be avoided, on account of the resulting thoracic and abdominal compression, causing diminution of thoracic space. Not only patients with sufficient compensation but those in whom it is insufficient, or in whom a circulatory balance has been effected by preceding treatment, must be kept to this gymnastic of the heart-muscle, and should repeat it after longer or shorter intervals of time, according to necessity. In methodical locomotion they possess a means of eminently strengthening the heart-muscle, and of maintaining or improving existing compensation. More precise directions will be given in the third part of this dietetic.

The *second* condition for strengthening the heart, is an efficient *nutrition* by a diet containing enough *albumen*, so that the tissues consumed during work may be replaced, and sufficient material be afforded for the formation of new tissue-elements, especially for the muscular hypertrophy. Since nutriment is afforded only by the blood, and is determined by its composition, this part of our task coincides with the second and is influenced by the same circumstances.

2. The second task is the *preservation of the normal composition of the blood.* By this we mean only that the blood must have the same number and relation of form-elements, the red and white corpuscles, and the same amount of serous albumen, as is normally the case. Upon the proper relation of the blood-constituents depends also, apart from the general nutrition, the oxidation of fat-forming substances, and, what is of special importance for the nutrition of the heart, the nutrition of the vessels, amongst which the capillaries and veins are under a higher blood-pressure than before, and when deranged in their nutrition suffer the escape of serum in large quantities, and thus œdema is facilitated.

Above all therefore the patients must endeavour to increase the albuminous constituents of the body by a large though not exclusive use of nitrogenous food rich in albumen, in order to supply as much albumen as possible to the blood, especially if at the same time it suffers continual loss by albuminuria, noticed or not. The diet therefore will be in the main a meat diet:

roast or boiled beef, beefsteak, veal, lean mutton, game. Eggs and leguminous substances are also useful, while fat and carbohydrates are allowable only in limited quantity, the latter being represented by 100 or 200 grms. of bread or starch-stuffs.

How long this diet must be adhered to, will depend upon the cause of the circulatory disorder. For some years certainly, and possibly throughout life, no great change must be made. Further, since the amount of corpuscles and albumen in the blood depends upon the amount of its diluting water, the supply of the latter in the food and drink must always be very strictly regulated, and mostly within very narrow limits, which must be determined by the amount of re-excretion which is possible.

3. *The regulation of the amount of body-fluid* demands the greatest attention and most strenuous supervision. The importance of this is not only curative but prophylactic. The conditions in question are purely physical. Owing to alterations which seldom or never permit of correction, occurring either in the pumping apparatus itself—the heart—or else in the vessels, an equal distribution of the blood is prevented and more or less stasis arises in one tubular system, namely, the venous. This stasis is still further increased by the disproportion between the renal excretion and the water supply. Certainly Nature by compensatory arrangements has provided for a kind of balance between the circulating fluids. But these arrangements fail when the quantity of fluids accumulated in the body becomes too great and there is not sufficient compensation. Unfortunately we cannot directly estimate the quantities in any special case, nor the exact limits between the supply and excretion of fluid. Nevertheless in the observable objective and subjective irregularities of the circulatory and respiratory apparatus, in the gradually increasing palpitation, in the respiratory embarrassment caused by locomotion and ascents, in the varying amount and consistency of the urine, and in the existence of albuminuria, we have *sufficient indications* by which to regulate the water-supply and to excite increased excretion from the skin and lungs. The feeling of thirst cannot be taken as a guide, as it is too variable, and depends a good deal on the amount the patient is used to. There are people

who are continually thirsty although drinking three or four times as much water as is necessary for the tissue-changes of the body, but who by-and-by accommodate themselves very well to a reduced quantity.

As a rule, the quantity of fluids permitted to the patient may be made very small: one cup of coffee or tea or milk or other liquid = 150 grms., $\frac{3}{8}$ litre of wine = 375 grms., and perhaps $\frac{1}{4}$ to $\frac{2}{3}$ litre of water, besides the water contained in the food, to which must be added a small plate of soup = 100 grms., at midday, will suffice very well for the necessary tissue-changes.

The proportion of fluid to be supplied is no constant one, but must be altered according to the evaporation depending on the external temperature, and according to the original cause underlying the circulatory derangement. The fluid supply will have to be a different one in valvular failure of the heart, or in obstruction of the pulmonary circulation from curvature of the spinal column, when compensation is restored, from what it will be in a patient who has suffered from obesity and fatty heart, and who has undergone a thorough fat-reduction. In the latter case the fluid supply may be a far larger one and the line may be drawn at liquids that are rich in carbohydrates, and which favour fat-formation, beer in particular. For the former cases, for patients with cardiac failure, compression of the lungs, and other irremediable mechanical derangements of the circulation, we shall have to restrict the supply of liquids to the smallest possible amount *all the patient's life*, if we desire to prevent that derangement from early attaining such a grade as to inevitably lead to a fatal result.

The general management of the patient from a prophylactic point of view, is not so difficult to carry out as might appear at first sight. The patients are soon accustomed to the surprisingly small quantity of fluid, especially when a long methodical treatment of the previous congestion has taken place.

Frequent rinsings of the mouth with cold water are useful, and lessen the feeling of thirst due to the previous large quantities of fluids imbibed. On the other hand the patients have little choice left them; either they must adopt the new mode of living and endure the restrictions laid upon them, or

else the circulatory evils will by-and-by increase to such an extent, that the patients will have to deny themselves these and other enjoyments, until after more or less suffering they obtain the desired relief.

The carrying out of the necessary restriction in the fluid-supply must meet with no opposition, but with the necessary energy on the part of the physician and the proper disposition of the patient must be done thoroughly and persistently.

The *watery excretions* also must be subjected to equal supervision and regulation. Upon this depends the unloading of the venous system, the vessels of which are under increasing pressure from the engorgement affecting the chief organs concerned, and favouring albuminuria. Both in cases with sufficient compensation from the first, and in those in whom it has been re-established, the slowly increasing derangement of the balance must be corrected by the simultaneous increase of the water-excretion from the skin and lungs. This must never be overlooked. As in stasis generally so here, the skin acts vicariously for the kidneys and causes lessening of the blood-volume and unloading of the lungs. But lessening the water of the blood is equivalent to increasing its solid constituents and albumen, with important consequences for cardiac and vascular nutrition.

The best means of exciting perspiration is *locomotion*, according to the particular case either walking on level ground or the ascent of elevations; and both form a 'gymnastic' for the heart. The patient should walk many times daily, and should ascend such heights as his strength permits; even going upstairs now and then does no harm, as the above case shows, but causes increased perspiration and strengthens the heart. Two or three times a year long mountain-tours must be made, according to the patient's capacity for work, which must be neither over- nor under-valued. At least two or three weeks in spring and from four to six weeks in autumn must be devoted by the patient to the preservation of his health. At such times he may very well ascend a good elevation—300 to 500 metres—above the valley-level, or even a mountain 800 to 1,000 metres high. To obtain the greatest advantage from such expeditions, the patient must adhere to or only very slightly exceed the restricted fluid supply. Exceptionally during

very arduous exertion, one-third more than the usual quantity may be permitted.

The *consequence* of such removal of water from the system is first shown in the urine, which is very scanty for the first few days and deposits urates abundantly. But when the immediate consequences of the muscular effort have subsided, the heart's action becomes stronger, slower, and more regular, the pulse is fuller, the breathing much freer, with deeper inspirations, and the patient feels more comfortable in every respect. Whenever practicable, excitation of sweating by *exercise* is far better than by any other method, and only when it cannot be thoroughly carried out may other means be substituted.

Next to exercise comes *dry heat*, in the form of hot air-baths—Turkish and sun-baths—by which copious sweating is induced (or moist heat, as in vapour-baths and packing). These may be used at several times of the year, during four to five weeks at a time, once or twice each week. There is a satisfactory water-removal by these means, but they do not exert the same influence upon the heart and lungs which exercise exerts, and thus their use is more restricted. They may be temporarily substituted for exercise, but cannot replace it entirely.

The same remarks apply to pilocarpine injections, used once or twice a week for several weeks together.

These measures must be connected with frequent walks and, whenever practicable, strenuous exertions, in order to excite and strengthen as much as possible cardiac action and respiration. Of course in all these methods of removing water from the system, the same restriction must obtain in the supply of liquids, if a real reduction of the body-fluid is desired.

The periodical removal of water from the skin and the unloading of the venous system and kidneys are indispensable in all cases in which, from pathological alterations in the heart or elsewhere in the circulation, a mechanical hindrance to the latter has developed, difficult to overcome; because the gradually arisen compensation never reproduces a perfectly normal condition, and the venous system is always comparatively overcharged. This overcharging very gradually undergoes a steady increase, and under an increased supply of liquids may rapidly develop

into a progressive stasis, too great for the existing compensation to overcome. Only by a *severe regulation* of the supply and excretion of water can we keep back continually the fatal symptoms, and successfully combat the long-existing and excessive hydrostatic derangement.

4. *The prevention of fatty heart and obesity.* The prevention of further fat-formation, or rather of fresh fatty deposition, is, wherever circulatory anomalies exist (especially after the restoration of previous compensations), a special task both of the essential treatment and of the succeeding dietetic.

A *general fat-reduction* has ensued without exception in all cases after a strict carrying out of the mechanical methods indicated and the connected regulation of the water-supply; it only remains to exert ourselves to keep the patient *in statu quo.* Where there is insufficient oxidation of accumulated fat, and where considerable venous stasis is already present, we must above all *avoid* attempting to reduce fat by *drink cures* of alkaline or iodine waters (Carlsbad, Marienbad, Kreuznach, Krankenheil, &c.), or allowing ourselves to be persuaded to agree to such. The first result of such treatment is not the desired one, but gradually, sooner or later, there is steady accumulation of the body-fluids, the fluid-excretion is less and less proportionate to the supply, the blood becomes more and more stagnant, and the advent is hastened of the terminal symptoms caused by insufficient circulation. I must repeat: in all cases of obesity and fatty heart where circulatory disorders are already present, we *must cast aside all methods which are opposed to the purely hydrostatic conditions which alone govern the situation,* all methods which can exert neither a physiological nor a pharmacological influence upon the disturbed balance between the arterial and venous apparatus. The patients came back from the baths in a worse plight than when they went away, and dropsy, usually progressive, which they now ascribe to the 'drink cure' alone, with the usual symptoms by-and-by ushers in death. It is indispensably necessary for the good reputation of these places, that such patients should be sent away by the resident physicians as soon as they present themselves, and told to adopt some other and more appropriate treatment.

We can with most certainty bring about a gradual fat-

reduction by maintaining, under certain modifications, the regimen by which the circulating disorders have been already corrected, and most of the accumulated fat already oxidised. The supply of fat and carbohydrates may be still restricted, and the walks, ascents, and expeditions persisted in, while the supply of liquids may be increased a little according to the amount and degree of concentration of the urine. But it is as well not to be too quick about the latter, for I have repeatedly noticed that an increased fluid supply has been followed not only by increase of weight, from retention of fluid in the body, but also by marked fatty deposition in various places from alteration of the circulation. If the fat-reduction has been a thorough one, to complete our task it only remains to keep back fat-formation, and the fatty degeneration of the heart therewith connected.

By a special diet carefully adhered to, it is not difficult to satisfy this requirement. The diet which the patient may henceforward adopt, may be a *more mixed* one if care be taken that it contain plenty of albumen. Moreover bread, sugar, and fat may be taken with impunity in not too great quantities, if only the supply of liquids be so restricted, that no derangement may arise in the circulation, and that the carbohydrates may be perfectly consumed. Beer is the worst of all liquids as a drink, as it is rich in carbohydrates and other fat-forming substances, and besides this it is usually taken to a larger extent than is possible without injury to the existing circulatory condition.

It will always be beneficial for the patient, besides the ordinary exercise prescribed, to undertake further two or three times a year long, difficult mountain-tours, and by increased sweating, the diminution of the fluid-supply, and the use of a more albuminous diet, to reduce any fat which has gradually re-accumulated, and remove any irregularities in the circulation.

Under this regimen the patient will maintain for years not only his blood-volume in a perfectly hydrostatic condition, but also his weight at an amount corresponding with his health. The health of such persons, their nutrition and blood-formation, the physiological functions of their respiratory, circulatory, and secretory organs, their powers of resistance to injurious influ-

ences, and their muscular capacities, will no longer differ from the normal, and their present condition will be as good as ever it was.

DIETARY.

The diet most suitable for maintaining the new condition will vary according to whether the previous disorders have been caused by organic alterations in the heart and lungs, or by simple obesity and fatty deposition on the heart; and while in the first case a rigid diet must be adhered to throughout life, in the second considerable concessions may be allowed.

After a careful observation of nine years, I find the following diet most suitable for patients of the first category:

Morning: One cup of coffee or tea with some milk = 150 grms. (6 oz.), and bread = 75 grms. ($2\frac{1}{2}$ oz.)

Midday: Soup = 100 grms. ($3\frac{1}{2}$ oz.); lean meat, roast or boiled, game or fowl = 200 grms. (7 oz.); fish, not too fat = 25 grms. (nearly 1 oz); bread or starch-stuffs = 100 grms. at most ($3\frac{1}{2}$ oz); as dessert 100 to 200 grms. ($3\frac{1}{2}$ to 7 oz.) of fruit—fresh preferred—a smaller quantity if preserved, especially by Nägeli's method. Liquids are better avoided at dinner-time; only in very hot weather or in the absence of fruit perhaps $\frac{1}{6}$ to $\frac{1}{4}$ litre of light wine may be allowed (6 to 9 oz.)

Afternoon: The same quantity of coffee or tea as before with at most $\frac{1}{6}$ litre of water (6 oz.), occasionally 25 grms. of bread (nearly 1 oz.)

Evening: One or two soft-boiled eggs, meat 150 grms. (nearly 5 oz.), bread 25 grms. (nearly 1 oz.), a bit of cheese, a little salad and fruit. As a regular drink $\frac{1}{6}$ to $\frac{1}{4}$ litre of wine (6 to 9 oz.), with perhaps $\frac{1}{8}$ litr of water ($4\frac{1}{2}$ oz.)

As a rule we must be careful never to allow much water at a time, but to distribute the daily allowance in small portions throughout the day. The supply of water contained in the solids is always better borne than water as such, because small quantities at a time reach the circulation, whence they can be easily excreted; thus no severe loading of the circulation arises.

Patients who have suffered from obesity and are quite cured, may take a little more fluid—a glass or two of wine at

midday, and in the evening $\frac{1}{2}$ a litre (about 17 oz.) of wine with $\frac{1}{4}$ litre (about 9 oz.) of water.

Beer also may be allowed as an exception, with careful regard to any increase of weight and fat-formation, and with an accurate estimate of the fat-equivalent contained—$\frac{1}{2}$ to 1 litre ($17\frac{1}{2}$ to 35 oz.) may be allowed in such cases. But it must be at once abandoned and the previous diet resumed, if any symptom of fat-accumulation arise. How far increased excretion of water may be necessary by exciting perspiration, or how far increased tissue-change or oxidation must be effected by locomotion and mountain-climbing, will in each case be determined by the severity of the symptoms.

Retrospect and General Conclusions.

From the results obtained in the cases described, we have discovered the interesting fact, that even in long-existing circulatory disorders, from whatever causes, the slowly developing symptoms are due exclusively to derangement of the hydrostatic balance.

It is not that the growth of the body increasing, with years, makes the previous compensations insufficient, but the morbid consequences develop simply from stagnation of a blood-volume that can no longer be driven forward, and a reconstruction of a previous compensation is still possible within wide limits. The treatment adopted against these disturbances must vary considerably from the older kinds of treatment, if we start from the suppositions we have shown to be correct, and we must above all oppose physical treatment against physical causes.

In the following table we see in the clearest manner the pathological alterations caused by the circulatory derangement, the indicated therapeutic problem, the means we have adopted, and the results we have obtained.

If, instead of the separate results and special therapeutic tasks indicated, we review the general result as regards the readjustment of the diseased organism, we must distinguish between alteration in the circulation caused by lesion of the circulatory apparatus on the one hand, which cannot be per-

Alterations in the organism;—object of treatment	Indications	Means employed	Result
1. Water-accumulation	Removal of water	Increased perspiration; restriction of liquids	General dehydration of body; thickening of the blood, and restoration of its normal composition
2. Diminution of albumen in the tissues	Albumen-supply	An albuminous diet	Albumen-loss made up; increased blood-formation
3. Diminished respiratory surface	Increased respiratory surface	Involuntary forced breathing in mountain-climbing, with powerful thoracic expansion	Enlargement of thoracic space; increased vital capacity
4. Diminished oxygen-supply	Increased oxygen-supply	Same as in last case	Increased gaseous exchange and arterialisation of blood; removal of cyanosis
5. Weakness of heart	'Gymnastic' of heart	Involuntary cardiac contractions caused by mountain-ascents	Strengthening of the heart; compensatory hypertrophy
6. Insufficient arterial filling	Increased artcrial filling	Strengthening the heart-muscle; cnlargement of respiratory surface, *i.e.* expansion of the thorax and increased pulmonary vascular capacity	Restoration of the hydrostatic balance
7. Overfilling of the veins	Unloading the venous system	Same as in last case	Same as in last case
8. Rcnal congestion	Unloading the kidncy	Removal of watcr from the body	Regulation of urinary excretion
9. Lessened oxidation	Increased oxidation	Incrcased respiratory surface; rclative and absolute increase of blood-cells; cessation of dyspnœa; increased oxygen-supply and increased muscular activity	Increased combustion of fat; rcduction of obesity

fectly removed, neither by nature nor by artificial help—the so-called irreparable organic alterations, *e.g.* spinal curvature, cardiac failure, struma, &c.—and, on the other hand, those circulatory alterations depending on a removable cause, such as insufficiency of the pumping apparatus, anæmia and atrophy of the heart-muscle, cardiac debility with deposition and infiltration of fat.

According to this distinction we effected—

1. In patients belonging to the *first* category, a restoration of the previous compensation, *i.e.* a return to the best possible condition in which such patients found themselves at any time when the compensation still preserved the hydrostatic balance :

2. In patients of the *second* category (with fatty heart), a readjustment of the circulatory apparatus, corresponding to the age and general condition.

In both classes to us is due the credit of the new status of the circulatory apparatus and the regained health, since without our interference the processes going on would have suffered no check, but would have hastened to a fatal result with increasing celerity.

The removal of water and *exercise* were the main features of this treatment, which enabled us to successfully oppose the morbid alterations resulting from the circulatory derangement. Of these two, the former, with the help of a diminished supply, was attained chiefly by the latter, and exercise itself had for its principal aim the excitation of the heart.

It has been attempted *for the first time*, by one of the most arduous kinds of exercises, viz. mountain-climbing, to act immediately upon the heart-muscle, and thus to cause powerful contractions. The result has justified the theoretical supposition with which we started at the introduction of our treatment. The same kind of exercise affected other parts and functions of the body which influence the circulation—to wit, the expansion of the thorax, the enlargement of the respiratory surface by the forced inspiration, the greater fulness of the arterial system, the greater supply of oxygen, and the increased oxidation.

The influence of mountain-ascents of 1,000 metres or more

above the valley-level upon the heart and lungs is a more powerful one than we can obtain by any other means. Such a perfect readjustment of circulatory derangement of so high a grade as described in the above cases *has never hitherto been effected*, and it well shows *what great modifications of the organism* and *what radical reconstructions are possible by physiological means.* Dehydration and mountain-climbing must henceforward be regarded as our chief aid in circulatory disease, venous stasis, cardiac debility (in tuberculosis), compression of the pulmonary circulation, diminished oxidation of the tissues, and fatty heart.

But also in its

Hygienic Aspect

this method will command the greatest attention. Not only have we a means, in cases where the circulatory apparatus is already deranged, of preventing the symptoms so threatening later on, and of procuring efficient and lasting compensation against a lesion irreparable in itself, but in the rearing of children, especially when there is congenital or early predisposition to inevitable circulatory disease, we must return to the above principles, both dietetically and in particular as regards the general development, the expansion of the thorax, and the strengthening of the muscles, above all the heart-muscle. We must no longer give such children as have been injured by scrofula or rickets an occupation which necessitates a sitting posture throughout the day for the greater part of the year, and which is connected with little or no bodily effort. The consequences of such a mode of bringing up or occupation are always shown in the backward development and small functional capacity of the body as a whole, and especially of the muscles (and heart).

Such children are fatigued by the least exertion; they suffer from palpitation and other symptoms of debility, to which soon succeed symptoms of circulatory derangement; they take no delight in muscular exercise or long walks, and in this respect are encouraged by their parents and friends. On the contrary, they should be put to such a business or calling as will demand bodily effort, and especially walking. If from the

circumstances of the case such a vocation cannot be selected, all their spare time should be filled up by exercises, gymnastics, and long trying walks. Such children should be sent to the hills as early as possible, to strengthen the heart-muscle by hill-climbing, increase the water-excretion from the skin and lungs, and regulate the circulation. But it is also self-evident that *healthy children*[1] *should be early accustomed to bodily exercises and hill-climbing*, in connection with the holiday expeditions under teachers, which are so beneficial. The endeavour to cultivate talent as far as possible must be subordinated to the requirements of the child's physical organism. Only in this way are we labouring for the future welfare of the race.

There remains only to *procure the means*, *i.e.* to select localities where ascents may be performed according to the preceding indications as adapted to the condition of the patient, and especially under professional control. I think there will be no difficulty in the realisation of the method in its widest sense. In our mountains of Bavaria, in Thuringia, in the North and South Tyrol, and in Switzerland there are elevations of between 100 and 1,000 metres high, in any number and of every choice, that might be thus utilised.

Moreover the mountain 'cure' resorts might easily be so adapted that it might be possible for a patient even in winter to undertake any necessary expedition for the sake of his health. Such places exist in the Northern Alps—Kreuth, Reichenhall, Partenkirchen—the excellent establishments in Appenzeller-land, in Switzerland, at Vierwaldstättersee, and other places, but *especially in the southern parts of the Alps*, above all Bozen, with its lovely mountains and high-lying valleys, also Gries, Meran, Arco, Montreux, &c. Here the patient would at the same time find himself under the care of experienced physicians, who would be able to regulate the necessary diet and to make proper choice and supervision of ascents, pushing on the over-anxious or lazy ones and restraining the over-zealous. To attempt the correction of circulatory irregularities, the reduction of fat, and the strengthening of the heart-muscle by

[1] I have accustomed my own children from an early age to long walks and mountain-ascents, and have obtained excellent results as regards their strength and bodily development.

the methods above given, apart from professional supervision, is not to be recommended. Repeated medical investigation and control of the results obtained, and estimates of the proper fluid-supply and excretion, and of the gradual increase of the heights to be ascended, are indispensable to the result, and must not be complacently disregarded by the patient.

The German-Austrian Alpine Club must be looked upon as a very useful institution in this respect, as by it a great number of hills and mountains in the Bavarian and Tyrolese Alps are made generally accessible and can be utilised therapeutically. This club has already done service sanitarily by exciting an interest in the Alps and giving an inducement to mountain-tours, thus promoting the gymnastic strengthening of the body; but we may most thankfully accept its aid, not only in making and keeping the body stronger, but in enabling us to completely remove derangements of the organism which formerly pursued a rapid and continuous course to a fatal end.

The proof of this lies in full before the reader.

TABLES

OF THE

CHEMICAL COMPOSITION OF NUTRITIVE AND OTHER ARTICLES OF FOOD IN THE COOKED AND UNCOOKED CONDITION.

For the further guidance of the physician in the arrangement of the diet, and to afford the necessary variety as far as the patient's condition allows, moreover to give a criterion as to the use or harm of any particular article, I supplement this treatise by the following tables, which show the percentage contents as to water, albumen, fat, and carbohydrates of a number of substances taken either for use or enjoyment.

A. *FOODS.*

Name	Water	Albumen	Fat	Carbohydrates	Analysis by
SOUPS.					
Plain soup . . .	99·1	—	0·8	—	Renk
Panada soup . . .	87·7	1·2	1·2	6·0	,,
Barley soup . . .	91·2	0·9	0·9	5·7	,,
Rice soup . . .	92·2	0·7	0·4	6·8	,,
Cabbage soup . . .	92·4	0·7	2·0	3·6	,,
Soup with toasted bread .	—	1·6	2·1	9·4	,,
Semolina soup . .	92·6	0·8	1·1	3·7	,,
Sago soup . . .	90·0	0·2	1·5	5·1	,,
Vermicelli soup . .	91·8	0·9	1·4	4·4	,,
Meat broth, with egg .	91·8	2·7	3·3	1·2	,,
Bread soup . . .	88·9	1·7	0·6	8·5	,,
Dumpling soup . .	79·1	2·7	1·2	15·2	Schuster
,, . .	67·4	6·3	7·5	18·8	,, (Renk)
Average of ten kinds .	91·6	1·1	1·5	5·7	Renk
Average of ten kinds, including two kinds of dumpling soup . .	83·2	2·6	3·2	9·7	,,

FOODS—*continued.*

Name	Water	Albumen	Fat	Carbo-hydrates	Analysis by
FLESH MEATS (per cent. composition of).					
a. BOILED OR ROAST.					
Tender beef, boiled . .	75·8	21·8	0·9	—	Renk
" " . .	66·5	28·4	1·3	—	Schuster
" " . .	66·6	25·5	1·5	—	"
Beef, boiled, with fat .	49·0	38·0	12·1	—	v. Voit
Veal	78·0	15·3	5·2	—	Renk
Beef, boiled . . .	56·8	34·2	7·5	0·4	König
" lean, browned .	59·0	38·2	1·7	—	v. Voit
Game, roast . . .	58·5	38·2	1·8	—	"
Roast pork, with fat .	40·0	34·6	24·2	—	"
" lean . .	69·0	20·0	10·0	—	"
Mutton, lean . . .	74·0	19·3	5·8	—	"
Veal, with fat and flour .	57·0	22·3	10·4	10·0	"
Average of meat soups .	58·0	38·2	2·7	—	"
Hash	72·0	9·7	6·3	9·0	Renk

b. RAW MEATS.

Since in roast meat most of the loss of weight (the only part of the loss concerned in our calculations, lying within wide limits) is due to loss of water, of which from 20 to 25 per cent.—on an average 22 per cent.—may be driven off, it will not be difficult to estimate the average percentage amounts of water, albumen, fat, and carbohydrates contained in roast meats from the following analyses by König :—

Beef, fat	55·42	17·19	26·38	—	Av. by König
" . moderately fat .	72·25	20·91	5·19	0·48	"
" lean . . .	76·71	20·78	1·50	—	"
Veal	72·31	18·88	7·41	0·07	"
Mutton, fat . . .	47·91	14·80	36·39	0·05	"
" less fat . .	75·99	17·11	5·77	—	"
Pork, fat	47·40	14·54	37·34	—	"
" lean . . .	72·57	20·25	6·81	—	"
Hare	74·16	23·34	1·13	0·19	"
Venison	75·76	19·77	1·92	1·42	"
Fowl, thin . . .	76·22	19·72	1·40	1·27	"
" fat . . .	70·06	18·49	9·34	1·20	"
Wild duck . . .	70·82	22·65	3·11	2·33	"
Partridge . . .	71·96	25·26	1·43	—	"
Fieldfare . . .	73·13	22·19	1·77	1·39	"
Pigeon	75·10	22·14	1·00	0·76	"

PRESERVED MEATS.

Smoked beef . . .	47·68	27·10	15·35	—	König
" tongue . .	35·74	24·31	31·61	—	"
Ham, Westphalian . .	27·98	23·27	36·48	—	"
" smoked . . .	59·73	25·08	8·11	—	Mène
Goose-breast, Pomeranian	41·35	21·45	31·49	1·15	"

FOODS—*continued.*

Name	Water	Albumen	Fat	Carbo-hydrates	Analysis by
		SAUSAGES.			
Sausage, Westphalian .	20·76	27·31	39·88	5·10	König
Pork sausage . . .	37·37	17·64	39·76	—	,,
Frankfort sausage . .	42·79	11·69	39·61	2·25	,,
Fried sausage . . .	63·90	18·30	14·50	—	v. Voit
Black sausage . . .	49·93	11·81	11·48	25·09	König
Liver sausage . . .	48·70	15·93	26·33	6·38	,,
		FISH.			
Caviar	53·80	25·10	13·1	—	König
Sprats	59·80	22·70	15·9	0·90	,,
Salmon, smoked . .	51·40	24·10	11·8	0·40	,,
,, fresh . . .	74·36	15·01	6·42	2·85	,,
Shellfish, fresh . .	80·97	17·09	0·34	—	,,
Smoked herring . .	69·49	21·12	8·51	—	,,
Pike, fresh . . .	79·59	18·34	0·51	0·63	,,
,, boiled . . .	74·70	22·10	0·60	0·70	,,
Carp, fresh . .	76·97	21·86	1·09	—	,,
Lobster	72·74	13·63	0·36	0·21	,,
Oysters	89·69	4·95	0·37	2·62	,,
		STARCH-STUFFS.			
Light pudding, baked .	56·7	8·7	6·2	16·0	Renk
Dumpling, in sauce .	66·6	3·2	8·8	16·0	,,
,, dried . .	51·4	10·9	12·0	33·5	,,
Vermicelli, in milk . .	77·2	7·5	4·3	14·2	,,
Boiled rice . . .	74·8	4·6	3·3	14·3	,,
,, semolina . .	83·2	3·0	2·5	8·2	,,
Flour pudding . .	79·0	5·2	4·2	10·4	,,
Macaroni	40·0	8·1	12·0	37·0	v. Voit
Pudding, boiled . .	55·6	6·31	14·6	22·73	,,
,, ...	48·1	6·13	15·19	29·8	,,
Average of seven lighter kinds	44·2	8·7	15·0	28·9	Renk
Another average . .	59·6	6·4	10·6	22·5	,,
		SALADS.			
		a. DRESSED.			
Potato salad	73·0	2·1	3·2	21·8	v. Voit
Green salad	97·6	0·5	0·3	1·5	Schuster
,, ,, ...	94·2	1·4	2·0	2·2	König
Preserved fruits . .	64·2	—	—	35·7	Renk
Average of fruits . .	85·0	0·3	—	15·0	v. Voit

FOODS—*continued.*

Name	Water	Albumen	Fat	Carbo-hydrates	Analysis by
		SALADS—*continued.*			
		b. UNDRESSED.			
Radish	86·92	1·92	0·11	8·43	König
,, young	93·34	1·23	0·15	3·79	,,
Sea kale	76·72	2·73	0·35	15·87	,,
Celery	84·09	1·48	0·39	11·80	,,
Onion	85·99	1·68	0·10	10·82	,,
Cucumber	95·60	1·62	0·09	2·28	,,
Asparagus	93·75	1·79	0·25	2·63	,,
Melon	89·87	0·96	0·28	7·14	,,
Green peas	78·44	6·35	0·53	12·00	,,
Sliced French beans in pod	88·75	2·72	0·14	6·60	,,
Cauliflower	90·89	2·48	0·34	4·55	,,
Lettuce-heads	94·33	1·41	0·31	2·19	,,
Endive-salad	94·13	1·76	0·13	2·58	,,
Wild herbs	93·41	2·09	0·41	2·73	,,
		VEGETABLES.			
		a. COOKED.			
Potatoes	70·0	1·8	3·1	24·0	Renk
Carrots	82·0	1·1	6·2	8·4	,,
Savoy cabbage	85·8	1·4	4·8	7·2	,,
Spinach	83·9	1·7	5·3	6·6	,,
Beans, dry	71·8	5·3	4·1	14·6	,,
Peas	69·5	4·4	4·4	12·2	,,
Kohl-rabi	82·5	1·5	5·2	9·8	,,
Red cabbage	83·2	1·3	5·3	7·7	,,
Turnips	82·5	1·1	6·2	8·9	,,
Potatoes	79·7	1·2	4·1	14·0	Schuster
Kohl-rabi	86·7	2·0	4·6	6·0	,,
Average of carrots, parsneps, &c.	72·3	2·2	3·9	18·1	Renk
Average of vegetables	62·2	6·4	1·4	30·0	v. Voit[1]
		b. UNCOOKED.			
Potatoes	75·48	1·95	0·15	20·69	Av. by König
Scorzonera	80·39	1·04	0·50	14·80	,,
Carrot	89·01	1·75	0·22	6·88	,,
Turnips	89·22	1·58	0·21	6·31	,,
Parsnep	83·91	2·08	0·11	11·72	,,
Kohl-rabi, underground part	85·89	2·87	0·21	8·18	,,
Kohl-rabi, leaves and stem	86·04	3·03	0·45	7·28	,,
Borecole	80·03	3·99	0·90	11·63	,,
Brussels sprouts	85·63	4·83	0·46	6·22	,,
Red cabbage	90·06	1·83	0·19	5·86	,,
Cabbage	89·97	1·89	0·20	4·87	,,
Spinach	88·47	3·49	0·58	4·44	,,

[1] See note on p. 271.

FOODS—*continued.*

Name	Water	Albumen	Fat	Carbo-hydrates	Analysis by
MUSHROOMS AND FUNGI.					
Agarici in general, fresh	86·94	3·64	0·31	6·84	Av. by König
„ „ dried	20·84	22·05	1·87	40·91	„
Mushrooms, fresh	91·28	3·63	0·18	2·91	„
„ dry	13·27	36·09	1·75	28·99	„
Truffles, fresh	72·30	8·65	0·47	10·73	„
„ dry	6·66	29·68	1·58	37·40	„
Morel	16·36	25·22	1·65	43·31	„
Boletus, varieties of	91·30	1·59	0·26	5·39	„
BREAD.					
Wheat bread, fine	35·59	7·06	0·46	56·58	Av. by König
„ coarse	40·45	6·15	0·44	51·12	„
Roll, Munich	28·00	9·60	1·00	60·00	Renk
Black bread	31·00	11·00	—	57·00	v. Voit
Rye bread	42·27	6·11	0·43	49·25	Av. by König
Pumpernickel	43·42	7·59	1·51	45·12	„
BISCUITS.					
Fine wheat biscuits	1·18	13·31	3·18	81·08	J. König and C. Krauch
Home-made „	10·07	11·93	7·47	68·67	„
English „	7·45	7·18	9 28	75·10	„
Gingerbread „	7·27	3·98	3·57	83·10	„
„ nuts	5·01	6·81	0·63	85·15	„
FRUIT.					
a. FRESH.					
Apples	84·79	0·36	—	13·00	Av. by König
Pears	83·03	0·36	—	11·80	„
Plums	84 86	0·40	—	8·24	„
Prunes	81·18	0·78	—	11·07	„
Peaches	80·03	0·65	—	11·65	„
Apricots	81·22	0·49	—	11·04	„
Cherries	79·82	0·67	—	12·00	„
Grapes	78·17	0·59	—	16·32	„
Strawberries	87·66	0·54	—	6·76	„
Raspberries	85·74	0·40	—	5 30	„
Red currants	84·77	0·51	—	7·28	„
Gooseberries	85·74	0·47	—	8·43	„
Bilberries	78·36	0·78	—	5·89	„

FOODS—*continued.*

Name	Water	Albumen	Fat	Carbo-hydrates	Analysis by
FRUIT—*continued.*					
b. DRIED.					
Prunes	29·30	2·25	0·49	62·32	Av. by König
Pears	29·41	2·07	0·35	58·80	,,
Apples	27·95	1·28	0·82	59·79	,,
Cherries	49·88	2·07	0·30	45·51	,,
Grapes	32·02	2·42	0·59	62·04	,,
Figs	31·20	4·01	—	49·79	,,
OTHER FRUITS.					
Almonds	5·39	24·18	53·68	7·23	Av. by König
Walnuts	4·68	16·37	62·86	7·89	,,
Hazelnuts	3·77	15·62	66·47	9·03	,,
Chesnuts	51·48	5·48	1·37	38·34	,,
MILK.					
Cow's milk	87·42	3·41	3·65	4·81	Av. by König
Cream	65·51	3·61	26·75	3·52	,,
Skimmed milk	90·66	3·11	0·74	4·75	,,
Butter milk	90·27	4·06	0·93	3·73	,,
Whey	93·24	0·85	0·23	4·70	,,
BUTTER AND CHEESE.					
Butter	14·49	0·71	83·27	0·58	Av. by König
Cream cheese	35·50	17·44	40·80	5·21	,,
Chester cheese	33·96	27·68	27·46	5·89	,,
LARD.					
Beef lard	0·71	0·12	99·10	—	Vienna Laboratory-Director
Pork ,,	0·70	0·26	99·04	—	J. König
EGGS.					
Eggs	73·67	12·55	12·11	0·55	Av. by König
Egg, white of	85·75	12·67	0·25	—	,,
,, yellow of	50·82	16·24	31·75	1·12	,,

Foods—*continued.*

Name	Water	Albumen	Fat	Carbo-hydrates	Analysis by
		SUGAR.			
Cane sugar	2·16	0·35	—	96·32	Av. by König
Molasses	35·06	—	—	53·06	„
		HONEY.			
Honey	19·61	1·20	73·72	—	—
		VINEGAR AND OIL.			
Vinegar	94·0	5·0	—	0·4	König
Oil	3·6	—	—	60·9	„

B. *DRINKS.*

Name	Water	Albumen	Fat	Carbo-hydrates	Analysis by
		WARM DRINKS.			
Tea	97·9	(Thein) 0·3	—	0·6	König (partly)
Coffee	94·7	(Caffein) 0·18	0·52	1·4	„
„ with milk . .	93·3	1·60	2·20	1·6	Renk
Chocolate, with milk .	89·0	3·70	3·60	3·8	„
Warm beer and egg .	91·6	2·70	2·10	3·5	„
		UNCOOKED MATERIAL.			
Coffee, raw . . .	10·13	(Plus caffein) 12·77	12·21	11·48	Av. by König
„ roasted . .	1·81	13·17	12·03	1·01	„
Solubility of roasted coffee in water . . .	(Total sol.) 25·50	3·12	5·18	—	„
Tea	11·49	(Plus thein) 22·57	4·29	23·88	„
Solubility of tea in water	(Total sol.) 33·64	12·38	17·61	—	„
Chocolate, sweet . .	1·55	(Plus theo-bromin) 5·06	15·25	74·84	„

DRINKS—*continued.*

Name	Water	Albumen	Fat	Carbo-hydrates	Analysis by
		BEER.			
Light winter beer	91·05	0·81	—	5·49	Av. by König
Lager, or summer beer	90·27	0·44	—	5·78	,,
Light beer	95·60	—	—	3·50	Renk
Export beer	89·21	0·44	—	6·48	Av. by König
		WINE.			
Must	74·49	0·28	—	25·51	König
Moselle	86·06	—	—	1·88	,,
Rheingau white wine	86·26	—	—	2·29	,,
,, red wine	86·88	—	—	3·04	,,
Ahr wine	87·25	0·29	—	2·58	,,
Rhenish red wine	87·44	—	—	3·01	,,
Rhenish white wine	86·92	—	—	2·01	,,
Hess. wine (Bergstrasse)	88·22	—	—	1·19	,,
Pfälzer wine	86·06	—	—	2·39	,,
Franken wine	89·92	—	—	1·25	,,
Baden wine	87·15	—	—	1·78	,,
Würtemberg wine	89·66	—	—	2·25	,,
Alsace white wine	88·27	0·15	—	1·79	,,
,, red wine	86·71	—	—	2·16	,,
Swiss white wine	88·57	—	—	1·87	,,
,, red wine	88·66	—	—	1·95	,,
Austrian red wine	87·80	—	—	2·71	,,
Bohemian white wine	85·92	—	—	1·99	,,
,, red wine	86·63	—	—	2·21	,,
Hungarian	84·75	—	—	3·05	,,
Burgundy	88·26	—	—	2·34	,,
Tyrolese wine	83·76	—	—	3·67	,,
Vorarlberg wine	87·93	—	—	2·41	,,
Champagne	77·60	0·21	—	13·16	,,
Rhine wine, still	80·09	0·28	—	10·19	,,
Cider, Swiss	91·15	—	—	2·53	,,
Perry ,,	91·77	—	—	3·17	,,
		SWEET WINES.			
Tokay	80·74	0·06	—	7·16	König
Port	77·42	0·17	—	6·00	,,
Madeira	79·12	0·18	—	5·10	,,
Malaga	71·16	0·20	—	17·09	,,
Marsala	78·97	0·19	—	4·46	,,
Sherry	79·52	0·20	—	3·27	,,
Muscat	68·39	0·14	—	18·45	,,

DRINKS—*continued.*

Name	Water	Albumen	Fat	Carbo-hydrates	Analysis by
		BRANDY AND LIQUEURS.			
Common brandy . .	55·00	—	—	—	König
Arrac	39·42	—	—	0·08	"
Cognac	29·85	—	—	0·65	"
Rum	47·34	—	—	1·26	"
Absinthe	40·33	—	—	0·77	"
Anisette	23·28	—	—	34·82	"
Curaçoa	16·40	—	—	28·60	"
Kümmel	34·08	—	—	32·02	"
Benedictine . . .	12·00	—	—	36·00	"
Ginger brandy . .	47·95	—	—	2·05	"
Punch, Swedish . .	37·09	—	—	36·61	"

REFERENCES.—V. Voit, *Untersuchung der Kost in einigen öffentlichen Anstalten*, compiled in combination with Dr. J. Forster, Dr. Fr. Renk, and Dr. Ad. Schuster. Munich, 1877. J. König, *Chemie der menschlichen Nahrungs- und Genussmittel.* Part i. 'Chemische Zusammensetzung der menschlichen Nahrungs- und Genussmittel,' 2nd edit., Berlin, 1882; and part ii. 'Die menschlichen Nahrungs- und Genussmittel: ihre Herstellung, Zusammensetzung und Beschaffenheit u.s.w.,' 2nd edit., Berlin, 1883.

Note.—Vide p. 266. In v. Voit's work, *Ueber die Ursachen der Fettablagerung*, the analysis of the vegetables on page 18 must be corrected by the preceding averages.

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